Second Generation Effects of N P K

on the Potato.

by

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CONTENTS

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SUMMARY

The experiment was designed to determine the effect of the rates of application of 0, 50, 100, 150, 200 units N/acre as ammonium sulphate in combination with 90 or 180 units P_2O_5/acre as superphosphate, and 135 or 270 units K_2O/acre as potassium chloride, to the parent crop, on the performance of the progeny tubers in the following year in the maincrop variety Kerr's Pink.

In the progeny growth year two size grades were planted in 1965 and 1966, and four in 1967. Final yields are available only for 1967, but the results of sprouting and of 3 samplings during growth are discussed for all 3 years.

The rate of N applied to the parent crop did not affect the final yield from the crop grown from the progeny tubers, but the increased N reserves of the progeny tubers did reduce intersprout and inter-stem competition in the early stages of growth, in the final two years, when the average N content of the parent tuber was lower than in the first year. This led to more vigorous shoot growth, and in one year root growth, followed by more rapid bulking of tubers in the early stages, with increased parent tuber N. The effect of the tuber N reserves on haulm was attenuated, soon after the end of tuber initiation; competition between tuber and shoot led to a relatively greater growth in the haulm, and subsequently to the yield of tubers on the lower N treatments equalling that on the higher.

The higher rate of K, in combination with 0 or 200 units N/acre, or with the higher rate of P, reduced the number of sprouts per tuber, the number of mainstems, number of tubers per hill, and in 1967 the final yield. This effect of K occurred most frequently in plants from larger tubers.

CHAPTER I

Introduction.

The experiments described in this thesis originated in an interest in whether or not an observation by Headford (1962) on laboratory grown potatoes could be confirmed in a field crop and whether or not yield would be influenced. It had been demonstrated by Headford that during sprout growth and the early stages of growth of the potato plant the major source of nutrient was the reserve substrate of the parent tuber.

There was also evidence that the N content of the parent tuber could be a limiting factor in sprout growth. A positive correlation between sprout size and percentage total N had been found by Headford (1962) and where sprout number per tuber was increased from 1 to 4, the % N in the D M of the sprouts was decreased from 3.31% to 2.91% (Headford 1961). This suggested intersprout competition for a limited N source in the parent tuber. Several papers were quoted, demonstrating the depletion of tuber nitrogen during sprouting (Denny 1929), (Carpenter 1957), (Street et al 1946). Sadler (1961) (quoted by Headford 1962) had found that an increase in sprout length at the time of planting from zero to 1.5 cm brought about a shortening of the period between planting and emergence and also between planting and tuber initiation.

Differences in the N content of tubers could therefore be expected to affect the sprout length and within the critical range of sprout lengths quoted, would consequently affect the time of emergence and tuber initiation. These effects could lead to differences in yield at final harvest depending on whether the shoot to tuber ratio at the time of tuber initiation was affected, and also on the subsequent growth conditions and the effect of treatment and season on maturity.

The quantity of nitrogen in a potato tuber is negligible; Headford (1961) quotes 1.24% of D M, and Hawkins (1946) quotes 1.78% N. The nitrogen content of tubers can vary, for example from 0.26% to 0.45% N in the fresh weight according to variety or the nitrogen status of the soil (Volkart 1948). At an average seed rate of 1 ton /acre the N supplied in the seed tubers could vary from 6 - 10 lb /acre. The total N uptake of a potato crop (soil + applied N) is quoted at 120 lb /acre by Simpson (1962), 100 - 180 lb /acre by Hawkins (1956), 60 - 100 lb /acre by Lorenz (1947), and will vary according to the length and favourableness of the growing season, the amount of N added and the amount of soil N. The N in the parent tuber forms only 5 - 10% of the total N in the final crop.

The level of tuber N can therefore be expected to influence growth largely through its effect on the early stages of growth, at which time the tuber N does form a substantial proportion of the total N content of the plant. The most obvious way of influencing the N content of a tuber is through the fertiliser applied to the parent crop.

The literature offers some information on the effect of fertilisers applied to the parent crop on the growth and development of the crop arising from the progeny. The work is largely Swiss or German in origin. Hofferbert and Putlitz (1956) observed differences in the early stages of growth in plants of the same variety grown under uniform conditions from tubers from different sources. The primary purpose of the long series of experiments was to investigate degeneration of stocks by virus diseases. Many of the differences between stocks could not be accounted for in terms of disease, and were ascribed to the differences in fertiliser treatment of the parent crop.

Volkart (1948) found no statistically significant effects of the N fertilisation of the parent crop, on the yield from the crop grown from the tubers produced, in a series of 48 trials. Pfeffer (1959), on the other hand, found some instances of response in the progeny to fertilisation of the parent crop. The treatments were nil fertiliser, a high and low rate of balanced fertiliser (N : P : K = 1 : 1 : 2) and a high N treatment (N : P : K = 2.5 : 1 : 2). The response in yield to fertiliser varied between 0 in one year and 18% in another year. Wunscher (1952) like Hofferbert and Pulitz (1956), while studying the effect of fertiliser on aphids and virus transmission in the potato, observed differences in crop growth from parent tubers produced from crop receiving differing fertiliser treatments. His experiments, designed to investigate this effect, led to the conclusion that neither by over-fertilising with one particular

fertiliser nor by the kind of potassium fertiliser used, nor by the use of common salt does one affect the second generation in climatically favourable years. He did, however, demonstrate differences in % of eyes sprouting at a given time, in the time of full flower, growth up to 6 weeks after planting and concluded that N was the most important single nutrient in the second generation effect.

Wunscher quotes Kottmeyer (1927) as having found effects of fertiliser in the next generation. Brandt and Sessous (1953) found that P increased the proportion of the total number of eyes per tuber to produce sprouts, and that there was a marked response in the general vigour of the sprouting and in the growth of the young plant to phosphatic manuring of the parent crop.

Both Kruger (1951) and Wunscher (1952) found that P applied alone to the parent crop delayed flowering in the progeny crop as compared with those plots receiving N. Birecki (1960) found small responses in total yield to balanced fertiliser as compared with nil and Fischich et al (1962) could find no response in yield.

Those workers who studied sprouting or the early stages of growth all found some response to the fertiliser applied to the parent crop. Only Pfeffer (1959) related this increased vigour to a feature of the parent tuber, in this case to the amide content of the tuber. A few noticed inconsistent responses in final yield, Wunscher (1952), Birecki (1960) and Pfeffer (1959).

Hofferbert and Putlitz (1956) also found responses in final yield to some of their treatments in 5 years of experiments, but since they appeared to repeat the fertiliser treatment of the parent crop on the progeny and expressed the progeny yield as a percentage of the parent crop yield, the results are difficult to interpret.

The effects of fertiliser treatment on the performance of the progeny tubers in the following year are likely to be small as compared with random errors from other sources. Most of the experiments quoted appeared to be examining too many factors with too little replication for small differences to be significant.

The rates of fertiliser used by the quoted workers were not high, particularly in respect of N (Table 1.1).

Table 1.1. The maximum rates of N P K applied to the parent crop in the experiments quoted.

Experimenters		N	$P_2 O_5$	$K_2 O$
		Kg/ha		
Volkart 1948	up to	90	50	70
Wunscher 1952		100	187.5	140
Brandt and Sessous 1953		40	120	160
Hofferbert and Putlitz 1956		100	187.5	140
Pfeffer 1959		100	72	160
Birecki 1960		30	30	60
Fischnich etal 1962		60	80	240

(conversion factor for converting from kg/ha to units /acre is 0.79, a fertiliser unit being 1% of 1 cwt of N, $P_2 O_5$ or $K_2 O$)

The response to the first increment of fertiliser after nil could be expected to produce the greatest response. It is, however, possible that higher rates could produce a change in direction of response.

It was decided to investigate by field experiment and to concentrate on the effect of one nutrient. In view of the observations of Pfeffer (1959) and of Wunscher (1952) that N was the most important nutrient, and Headford's observations on the competition for N between sprouts (Headford 1962), N was selected. The use of several uniform increments would allow a parametric analysis of the data and provide the opportunity to use orthogonal polynomials in deriving regression equations. A currently standard dressing of 100 units /acre N was selected as the mid point of the range and the maximum was double this quantity, which, with a 50 unit increment gave N treatments of 0, 50, 100, 150, 200 units N/acre.

Nitrogen fertilisation could be expected to influence the tubers harvested from a crop in several ways. The maturity of the tubers at harvest could be affected in that increasing nitrogen generally delays maturity. If the haulms on the treated plots were destroyed at the same time, this maturity effect would be present in the tubers. The effect of differences in maturity on the rest period was investigated by Emilsson (1949) who had demonstrated a gradual decrease in the length of the rest period with increasing maturity at harvest. He did not, however, find any

consistent influence on the rest period with fairly large applications of N P K in all combinations.

Nitrogen would directly affect the composition of the tubers. Holliday (1963), for example, had shown that dry matter percentage was affected by N fertilisation. Volkart (1948) demonstrated that the N content of the tubers was influenced by nitrogenous fertilisers, and specifically the amide content was increased. Emilsson and Lindblom (1963) gave a review of the nitrogen metabolism of the potato tuber. The author of this thesis did not propose to investigate the physiology of the tuber but to look for field effects, ultimately perhaps, on yield.

The experiments were designed to study the effect of N with some precision. Two P and K levels were included in order to balance the different levels of N in a reasonable approximation to accepted N P K ratios for potato fertilisers. Two levels of P and K were chosen, the lower would balance 100 units /acre of N and the higher, 200 units /acre of N. These are defined later, in Chapter 2.

One of the effects of differing fertiliser treatments is to change the size distribution of the tubers produced (Ivins 1963).

This effect could be expressed in the following year as a size of seed effect if the spacing of the planted tubers were constant (Bremner and El Saeed 1963) since there could be quite a large effect on the mean weight of tuber within each size grade even within the normal seed size range of 1¼" - 2¼" diameter. In order to reduce variation due to this cause, and in order to distinguish more clearly the effects of treatment on the tubers

per se, the seed was graded into closely sized groups each year as described in Chapter 2.

In order to avoid a year's delay whilst treated seed was being grown, seed was obtained from current (1963) experiments involving different rates of application of N P K to potatoes, either in constant ratios, or with P K constant and N varied from nil to 200 units / acre in 50 unit intervals. The quantity of seed obtained was small, and the field experiment provided too few replications, (4), for possible differences to achieve significance in the circumstances of a very high coefficient of variation. This variation was largely due to residual N effects from previous soil treatments. These experiments will not be quoted further, other than to state that differences in time of sprouting, sprout lengths and numbers per tuber, on both single sprouted tubers (sprouted in November at 20° C) or multisprouted tubers (sprouted in February at 15° C), were not related significantly to N treatments, other than that total length of sprout per tuber was increased by successive increments of complete balanced fertiliser.

The methods and results of the main experiments are presented in subsequent chapters. <u>It is suggested that for a first full reading of this thesis Chapters 5, 6 and 7 be omitted except perhaps for the summaries at the end of each.</u>

1964-65 & 1965-66.

Production year

Produce from one plot e.g. N_1 P_2 K_1

Growth year

graded $2\frac{1}{4}$", $2\frac{1}{4}$ - $1\frac{3}{4}$", $1\frac{3}{4}$ - $1\frac{1}{4}$", $1\frac{1}{4}$"

discarded discarded

Main plot	Large seed		Small seed	
Replicate	I	II	I	II

Field plot planted

Replicate	-	I	Replicate	- I
Main plot	-	large seed	small seed	
Sub plot	-	P_2 K_1	P_2 K_1	
Sub-sub plot	-	N_1	N_1	

1966 - 67

Growth year

Blocks 4 size grades

Main plot P K 2 2

Sub-plots N 5

CHAPTER 2

METHODS.

Seed potatoes were produced under differing fertiliser treatments, sprouted, planted under uniform conditions in the following year and the yield determined. The first year's seed production crop will be called the parent crop and the second stage in the growth year, the progeny crop.

In 1964/65, 1965/66 the seed from each production plot was divided into 2 size grades, and subdivided into two replicates, thus, seed from each of the 20 production plots was planted in 4 growth plots. (See opposite).

In 1966/67 the seed was divided into 4 size grades in an attempt to reduce experimental error and give more degrees of freedom for the error appropriate to the effect of nitrogen. Seed size was completely confounded with blocks.

SEED PRODUCTION

Treatments.

Seed was produced under the same N, P, K, treatments in 1964, 1965 & 1966. The treatments were:

P_1 = 90, P_2 = 180 units $P_2 O_5$ /acre (1)

K_1 = 135, K_2 = 270 units K_2 O /acre

Main plots = all 4 combinations of P & K.

Sub-plots N_o N_1 N_2 N_3 N_4

N = 0, 50, 100, 150, 200 units N/acre

No replication was provided in the production plots.

The nitrogen rates were chosen to provide a range on either side of the average optimal application for yield, 100 units N/acre, in the production year (Smith & Simpson 1957). The lower rates of P and K were the recommended rates for these nutrients, and the higher rate, double this rate. Thus a combination of 100 units N, 90 units $P_2 O_5$ and 135 units K_2 O per acre (N_2 P_1 K_1) could be regarded as a standard.

The variety was Kerr's Pink and the seed was of either Foundation or Stock Seed (Scot.) grade. The seed was not pre-sprouted in the seed production year.

Soil Type

	Soil series	Description
1964	Darvel	Fluvioglacial sands and gravels, freely drained.
1965	Macmerry	Clay loam, freely drained.
1966	Easter Bush	As Darvel, but imperfectly drained.

(1) A unit of nutrient is 1% of 1 cwt. of fertiliser, 1 cwt of fertiliser of 20% N = 20 units. N

Growth year.

The second stage or growth year will be regarded as starting at the lifting of the tubers in the production plots. The tubers from each plot were bagged separately and stored in sacks until November, when they were dressed and graded into 1¾-2¼", 1¼-1¾", and stored in bags until the end of December when the tubers were regraded and boxed.

Tuber-size grading.

The seed produced in 1964 and 1965 was divided into two size classes based on the riddle sizes 1¼-1¾" (small seed) and 1¾-2¼" (large seed). Seed in these classes was selected by eye to approximate to a median size in each class and batches of 40 were adjusted to a constant total weight. This gave tubers of the following average weight in each year.

	1964	1965
Large seed	106 g	105 g
Small seed	42 g	58 g

In 1966 - the two riddled grades were subdivided into two classes by weighing each tuber and allocating it to the following grades:

Riddle grade	Seed grade	Weight class limits	Range
1¼ - 1¾"	1	28 - 44 g	16 g
	2	45 - 66 g	21 g
1¾ - 2¼"	3	67 - 84 g	18 g
	4	85 - 122 g	37 g

The wider range in the largest seed class was required to obtain enough seed, but is in fact a smaller proportionate range.

Sprouting

Graded tubers were placed in a single layer in standard sprouting boxes at the end of December. The position in the store of each treatment was randomised and the piles of boxes were restacked during the winter, with the lowest box placed on top of the pile, during re-stacking, to minimise temperature differences due to position. The storage building was of thick stone and held a temperature fluctuating slowly between 40° - 50° F. during the storage period. The tubers were continuously illuminated by white fluorescent tubes standing vertically between two rows of stacks, one light to six stacks.

Each box contained tubers sufficient to plant a field plot with a 50% excess to allow for the discarding of diseased tubers before planting.

Records of sprout growth

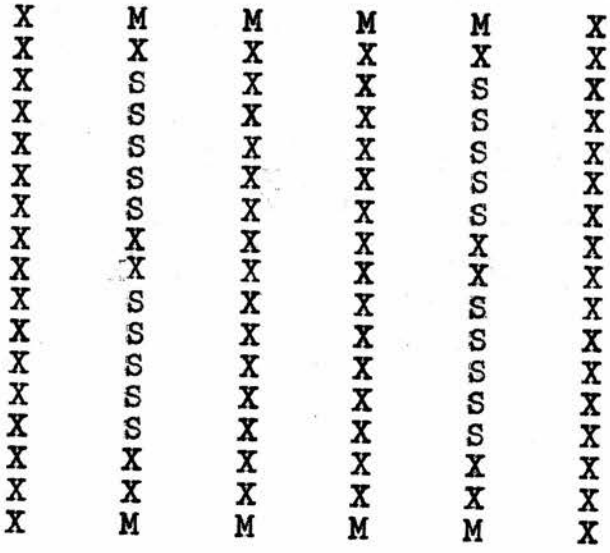
1964 - 65 On 16th April, 1965, the number and length of sprouts was recorded on 10 tubers from each box (8-10% of total), that is 20 tubers for each N P K treatment or 160 tubers for each rate of N.

1965 - 66 On 11th April, 1966, the number and length of sprouts was recorded on 10 tubers from each box and the number of eyes producing sprouts was recorded on 100 tubers from each box.

1966 - 67 On 26th March, 1967, number and length of sprouts was recorded on 20 tubers from each box or sub-sub plot.

Plot design

Final yield area
10 tubers per
drill



Growth sampling
area
15 tubers per
drill

Key:

X Treated Kerr's Pink tuber

S Growth sample treated Kerr's Pink tuber

M Majestic marker

Measurement of sprout length

A lower limit of 3 m m sprout length was set below which an eye was not regarded as having commenced growth. This was set at a measurable length in order to avoid ambiguity.

Growth year field experiment design.

The experiments were of split-split plot design. In 1965 and 1966 the following layout was used: 2 replicates, main plots = 2 seed sizes, sub plots = 4 combinations of P and K, sub-sub plots = 5 levels of N.(1) In 1967, the design was changed to give more degrees of freedom in the error applicable to N. There were no replicates but there were 4 sizes of tubers with 4 P, K, and 5 N levels as before. In the first two years the plots were 6 drills wide (14 ft.) and 39 feet long and tubers were spaced 16 inches apart in the drills. See plot design on opposite page. 1967 - similar to previous years except that only 5 drills were planted, 2 guard and 3 treated drills. Plot length and spacing were the same as in the previous year.

Fertiliser in growth year.

70 units N, 70 units $P_2 O_5$ and 140 units $K_2 O$ per acre were applied as granular fertiliser in the previous formed ridges before hand planting and splitting of the ridges.

Weed control.

Linuron and paraquat were applied at recommended rates before emergence of the crop. This gave satisfactory weed control each year.

(1) See Appendix for notes on analysis of variance

Blight Control Sprays.

The experimental area was treated to prevent blight at the same time as the farm crops. Two extra drills were planted between each two rows of plots to allow the spraying tractor access without damaging the plots. In no year did blight become established in the crop.

Soil Type	Field	Soil series	
1965	Dryden	Darvel	Fluvioglacial sands and gravels, freely drained.
1966	Longrigg	Macmerry	Clay-loam with partially sorted upper horizons, freely drained.
1967	Laundry	Darvel	

Growth Sampling

The sampling unit was a row of 5 contiguous plants taken from the sampling area on a regular pattern. Each sampled drill had guard drills on either side and three guard plants were left between two contiguous sampled lengths. Samples were dug by fork and washed free of earth.

Sampling Dates.

	1965		1966		1967	
	Date	Wks after planting	Date	Wks after planting	Date	Wks after planting
Planting	6/5/65		4/5/66		12/4/67	
1st sample	8/5/65	4½	13/6/66	5½	5/6/67	8
2nd sample	28/6/65	7½	28/6/66	7½	26/6/67	11
3rd sample	28/7/65	12	1/8/66	12	31/7/67	16
Final Harvest (Haulms destroyed)	2/10/65	21	not harvested		13/10/67	26

1st Sampling - the following were measured:-

1. Mainstem numbers - a mainstem is any stem arising from the seed tuber.
2. Dry Weight of stem and leaves - roots were removed and the entire stems, leaves and stolons were oven dried for 24 hours and weighed.
3. Dry weight of roots - oven dry weight.
4. Dry weight of parent tuber - oven dry weight (1967 only).
5. Number of nodes below ground level - recorded only in 1965.

2nd Sampling - As for 1st sampling except that the parent tubers were not weighed. In addition the number and fresh weight of tubers was recorded.

3rd Sampling - Number and weight of tubers only was recorded, other than in 1967, when the fresh weight of stems and leaves was recorded in addition.

Haulm destruction - the haulms were destroyed with Reglone.

Final harvest - The plots were harvested with an elevator digger, after the guard plants had been dug by hand. In 1965, there were 32 plants per sub-sub plot for final harvest, and in 1967, 24 plants. The tubers were bagged, and at a later date, graded into $>2\frac{1}{4}$", $2\frac{1}{4}$ - $1\frac{3}{4}$", $1\frac{3}{4}$ - $1\frac{1}{4}$", $<1\frac{1}{4}$", weighed and counted.

Rhizoctonia and coiled sprout - In 1966, the number of plants showing symptoms of these diseases was recorded at the second sampling and, in 1967, at the first and second sampling. As these showed no relationship to treatment and were almost the same in each plot they will not be quoted.

Note on covering of tubers in 1965 growth plots.

The ridging bodies used in covering the seed in 1965 were mis-aligned and the plants emerged through the side rather than the apex of the drill. In view of the importance of relative rates of emergence of the N treatments the validity of interpreting the results of this experiment must be in doubt.

CHAPTER 3

Results from the Production Years

The effect of N P K on the yield of potatoes greater than 1¼" diameter.

Production Year 1964.

The average yield from the experiment was 25 tons / acre. Increasing rates of application of N increased the yield of tubers larger than 1¼" diameter (Linear effect sig $P < 0.01$) (Table 3.1). There was a reduced response to each successive increment up to 150 units N/acre and a negative response between 150 and 200 units N/acre (quadratic effect $P < 0.05$). There was no interaction between P or K and N. With only one degree of freedom in the error for P and K little statistical evidence is forthcoming on their main effects. By inspection P had no effect, and the higher rate of K outyielded the lower rate by about 5% (Table 3.2).

Production Year 1965.

The average yield from the experiment was 12 tons /acre. The yield increased with increasing rates of N (linear effect $P < 0.01$) (Table 3.1) and, as in the previous year the rate of increase diminished with successive increments until between

150 and 200 units the response was negative. There was no interaction between P or K and N. By inspection, an increase in neither P nor K affected yield and the combination of the lower rates yielded as well as other combinations (Table 3.2).

Production year 1966

The average yield was low in this year at 8.5 tons /acre. The crop was planted late and the soil was poor, the differences in yield between nil N and the best treatment was 127% as compared with 83% in the previous year and 32% in the high yielding first year.

There was a positive linear response to increasing N applications ($P < 0.01$) but the response to the first increment was very low (Table 3.1). The greatest response was between 50 and 100 units and although 150 units N/acre outyielded 200 units the quadratic effect was non-significant. There was no interaction between P or K and N. By inspection (Table 3.1), there was some reduction in yield at the higher level of P, but since the coefficient of variation for the experiment was very high (27.5%) no conclusion can be drawn from this as to the effect of P. There was little difference between the levels of K but the combination of K_1 and P_2 produced the lowest yield of the four P K combinations.

All 3 years combined.

Nitrogen increased yield (linear effect sig $P<0.01$) (Table 3.1), but there was a diminution in response at higher rates and a negative response to the last increment (quadratic effect sig $P<0.01$) (Table 3.1). Neither P nor K affected yield and none of the interactions were significant.

Seed Production yields.

Table 3.1. The effect of N on the yield of tubers >1¼" (cwt /acre).

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1964	427.6	508.2	543.5	564.4	527.2	± 20.56	L .01 Q .05	8
1965	150.4	244.6	250.0	275.4	270.0	± 15.61	L .01 Q .05	13
1966	100.6	116.0	204.7	227.4	206.5	± 23.56	L .01	27
1964-66	226.2	289.6	332.8	355.7	334.6	± 10.67	L .01 Q .01	12

L = linear effect

Q = quadratic effect

Table 3.2. The effect of P and K on the yield of tubers > 1¾" (cwt./acre)

1964

Units /acre	K_1 135	K_2 270	Mean
P_1 90	479.0	546.4	512.7
P_2 180	516.0	515.3	515.6
Mean	497.5	530.8	

No standard errors available for P and K in any year

1965

Units /acre	K_1 135	K_2 270	Mean
P_1 90	237.7	232.6	235.2
P_2 180	245.7	236.3	241.0
Mean	241.7	234.4	

1966

Units /acre	K_1 135	K_2 270	Mean
P_1 90	189.9	174.7	182.3
P_2 180	136.2	183.3	159.8
Mean	163.1	179.0	

1964 - 1966

Units /acre	K_1 135	K_2 270	Mean
P_1 90	302.2	317.9	310.1
P_2 180	299.3	311.6	305.5
Mean	300.8	314.8	

CHAPTER 4

Results from the Growth Years.

In the account of the results of the experiments in subsequent chapters, each growth year's results are in separate chapters. In order to facilitate comparison between years, the salient tables for all 3 years of the main effect of N, two way tables for P and K and a few others, have been grouped together in this chapter. All these tables have the number 4 as the first number in their reference number. The two way tables for the interaction of N with one of the other variables are given within the text of the years in which the interactions were significant. All these tables have the chapter number as a prefix followed by the appropriate section and subsection numbers.

The S E is given after the means, and the level at which the F ratio is significant is indicated in the column after the S E in tables for N. Where the effect component is appropriate an L = linear or Q = quadratic is interposed.

The 1st and 2nd samplings of the number of mainstems per hill were considered to be samples of the same populations for each plot, and were averaged for analysis. For discussion of the interdependence of mainstems with other variates at a specific sampling, the appropriate sampling estimate of mainstems was used.

A summary of Chapters 5, 6, and 7 will be found at the end of each chapter.

Analysis of seed.

The effect of N P K applied to the parent crop on the analysis of the seed tubers produced.

Table 4.1. Effect of N on % N in D M of seed tubers.

Units /acre N	N_0 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P <	C V %
1964-65	1.19	1.40	1.59	1.69	1.85	± 0.050	.01	3.2
1965-66	1.00	1.09	1.33	1.46	1.79	± 0.045	.01	7.5
1966-67	0.97	1.00	1.10	1.31	1.47	± 0.018	.01	8.9

Table 4. 2 Effect of P and K on % N in D M of seed tubers.

1964-65

Units /acre	K_1 135	K_2 270	Mean
P_1 90	1.53	1.56	1.54
P_2 180	1.52	1.57	1.54
Mean	1.52	1.56	

No S E available

1965-66

Units /acre	K_1 135	K_2 270	Mean
P_1 90	1.34	1.37	1.35
P_2 180	1.32	1.35	1.32
Mean	1.32	1.35	

1966-67

Units /acre		K_1 135	K_2 270	Mean		
P_1	90	1.18	1.16	1.17	S E for means	± 0.0158
P_2	180	1.11	1.23	1.17	S E for comparisons within table	± 0.0224
	Mean	1.14	1.19		C V 2.1%	

Table 4.3. Effect of N on % N in fresh weight of tuber.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1964-65	0.28	0.32	0.36	0.37	0.39	± 0.005	L.01	3.7
1965-66	0.21	0.23	0.29	0.31	0.37	± 0.009		7.4
1966-67	0.21	0.21	0.23	0.27	0.29	± 0.005	L.01 Q.01	8.6

Table 4.4. Effect of P and K on % N in fresh weight of seed tuber.

1964-65

Units /acre		K_1 135	K_2 270	Mean
P_1	90	0.341	0.336	0.338
P_2	180	0.345	0.340	0.343
	Mean	0.343	0.338	

No S E available

1965-66

Units /acre	K_1 135	K_2 270	Mean
P_1 90	0.29	0.28	0.29
P_2 180	0.28	0.27	0.28
Mean	0.29	0.28	

No S E available

1966-67

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	0.26	0.23	0.24	S E for means	± 0.003
P_2 180	0.23	0.25	0.24	S E for comparisons within table	± 0.004
Mean	0.24	0.24			
P K interaction sig ($P<.01$).				C V 2.49%	

Table 4.5. Effect of N on D M % of seed tubers.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1964-65	23.2	22.5	22.6	21.8	21.0	± 0.25	.05	3.2
1965-66	21.1	21.2	21.4	21.4	20.6	± 0.17		1.8
1966-67	22.2	21.3	20.9	20.3	19.5	± 0.30	.05	5.7

Table 4.6. Effect of P and K on D M % of seed tubers.

1964-65

Units /acre		K_1 135	K_2 270	Mean
P_1	90	22.4	21.7	22.0
P_2	180	23.0	21.8	22.4
Mean		22.7	21.7	

No S E available

1965-66

Units /acre		K_1 135	K_2 270	Mean
P_1	90	21.9	20.4	21.1
P_2	180	21.7	20.4	21.0
Mean		21.8	20.4	

No S E available

1966-67

Units /acre		K_1 135	K_2 270	Mean
P_1	90	21.9	20.2	21.1
P_2	180	21.0	20.2	20.6
Mean		21.5	20.2	

S E for Means ± 0.189

S E for comparisons within table ± 0.268

Main effect of K sig ($P < .01$)

C V 2.04%

The effect of N P K applied to the parent crop on the sprouting of the progeny tubers.

Table 4.7. Effect of N on number of sprouts per tuber.

Units /acre N	N_0 0	N_1 50	N_2 100	N_3 150	N_4 200		S E	F Sig. P<	C V %
1964-65	6.81	6.63	7.69	8.02	7.02	±	0.285		14.2
1965-66	3.61	3.89	3.82	3.61	3.79	±	0.057	(a)	6.0
1966-67	2.46	2.61	2.77	2.61	2.73	±	0.073	L .05	11.1

Notes (a) N residual sig. ($P < 0.05$), linear and quadratic not sig.

L = linear effect

Table 4.8. Effect of P and K on number of sprouts per tuber.

1964-65

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	7.32	5.81	6.57	S E for means	0.285
P_2 180	7.86	7.95	7.91	S E for comparisons within table	0.403
Mean	7.59	6.88			
Main effect of P sig ($P < .05$)				C V = 22.3%	

1965-66

Units /acre	K_1 135	K_2 270	Mean	
P_1 90	3.97	3.97	3.97	S E for means ± 0.057
P_2 180	3.89	3.14	3.52	S E for comparisons within table ± 0.080
Mean	3.93	3.55		

Main effect of P and K sig.($P < .05$)

C V = 6.0%

Interaction of P and K sig.($P < .05$)

1966-67

Units /acre	K_1 135	K_2 270	Mean	
P_1 90	2.42	2.68	2.55	S E for means ± 0.036
P_2 180	3.04	2.40	2.72	S E for comparisons within table ± 0.051
Mean	2.73	2.54		

Main effects of P and K sig. ($P < .01$)

C V = 3.9%

Table 4.9. Effect of N on the total length of sprout per tuber (m m).

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P <	C V %
1964-65	44.11	44.54	48.88	46.41	47.19	± 2.449		14.9
1965-66	39.29	45.88	46.17	46.64	47.22	± 2.087	L.05	13.1
1966-67	28.5	31.7	35.7	33.4	36.3	± 0.93	L.01	11.2

Table 4.10. The effect of P and K on the total length of sprout per tuber (m m).

1964-65

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	44.19	46.82	45.51	S E for means	± 1.470
P_2 180	44.40	49.49	46.95	S E for comparisons within table	± 2.079
Mean	44.30	48.16		C V = 14.9%	

1965-66

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	46.64	43.11	44.87	S E for means	± 0.895
P_2 180	45.63	44.78	45.20	S E for comparisons within table	± 1.266
Mean	46.13	43.94		C V=13.1%	

1966-67

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	33.3	31.9	32.6	S E for means	± 0.46
P_2 180	35.1	32.2	33.7	S E for comparisons within table	± 0.65
Mean	34.2	32.1		C V = 3.9%	

Main effect of K sig ($P < .01$)

Table 4.11. The effect of N on mean length of sprout (m m).

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1964-65	6.64	6.75	6.30	5.93	6.81	± 0.281		12.2
1965-66	10.13	10.64	10.15	11.34	11.02	± 0.379		10.0
1966-67	11.72	12.07	12.96	13.07	13.38	± 0.282	L .01	7.7

Table 4.12. The effect of P and K on mean length of sprout (m m).

1964-65

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	6.08	8.01	7.04	S E for means	± 0.229
P_2 180	5.66	6.20	5.93	S E for comparisons within table	± 0.324
Mean	5.87	7.10		C V = 12.2%	

Main effect of P and K sig. (P<.05)

1965-66

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	10.34	10.30	10.32	S E for means	± 0.147
P_2 180	9.94	12.04	10.99	S E for comparisons within table	± 0.208
Mean	10.14	11.17		C V = 10.0%	

1966-67

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	13.75	11.88	12.82	S E for means	± 0.28
P_2 180	11.52	13.41	12.46	S E for comparisons with table	± 0.40
Mean	12.64	12.64		C V = 6.3%	

P K interaction sig (P<.01)

Table 4.13 The effect of N on the percentage emergence of the progeny crop at one point of time during emergence.

Units /acre N	N_0 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1965-66	68.3	70.8	71.9	71.0	78.4	± 1.66	L.01	9.2
1966-67	17.6	16.8	19.2	19.8	19.4	± 0.51	Q.05 L.01	11.0

Table 4.14 The effect of P and K on the percentage emergence of the progeny crop at one point of time during emergence.

1965-66

Units /acre		K_1 135	K_2 270	Mean		
P_1	90	72.3	78.5	75.4	S E for means	± 1.28
P_2	180	73.9	64.3	68.8	S E for comparisons within table	± 1.80
	Mean	72.8	71.4		C V = 11.2%	

Main effect of P sig (P<.05)

Interaction of P and K sig (P<.01)

1966-67

Units /acre		K_1 135	K_2 270	Mean		
P_1	90	19.35	19.15	19.25	S E for means	± 0.338
P_2	180	18.10	17.75	17.93	S E for comparisons within table	± 0.478
	Mean	18.73	18.45		C V = 5.14%	

Main effect of P sig (P<.05)

The effect of N P K applied to the parent crop on the growth of the progeny crop at the 1st sampling.

Table 4.15. The effect of N on weight (g) D M in the stems, leaves and stolons.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1964-65	2.9	3.4	3.5	3.2	3.5	± 0.29		37.4
1965-66	7.7	8.1	8.0	7.4	9.4	± 0.59		21.1
1966-67	5.7	5.7	6.5	7.1	7.2	± 0.33	L .01	20.3

Table 4.16. The effect of N on weight (g) of dry matter in roots at 1st sampling.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1964-65	0.61	0.64	0.63	0.59	0.61	± 0.052		33.5
1965-66	1.11	1.15	1.12	1.09	1.19	± 0.047		17.6
1966-67	0.70	0.77	0.79	0.84	0.81	± 0.41	L. 05	21.1

Table 4.17. The effect of N on weight (g) of dry matter, in parent seed tuber at 1st sampling.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1966-67	5.34	4.99	4.44	4.14	3.69	± 0.199	L.01	17.6

Table 4.18. The effect of P and K on weight (g) of dry matter in parent seed tuber at 1st sampling.

1966-67

	K_1	K_2			
Units /acre	135	270	Mean		
P_1 90	4.91	4.11	4.51	S E for means	± 0.111
P_2 180	4.35	4.73	4.54	S E for comparisons within table	± 0.157
Mean	4.63	4.42			

Interaction of P and K sig. ($P < .01$) C V = 6.9%

Table 4.19. The effect of N on the number of mainstems per hill, 1st and 2nd samplings combined.

Units /acre	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1964-65	3.3	3.3	3.5	3.2	3.6	±0.20		23.0
1965-66	3.0	3.0	2.9	3.0	3.1	±0.07		9.3
1966-67	2.1	2.3	2.4	2.3	2.4	±0.08	L.05	14.5

Table 4.20. The effect of P and K on the number of mainstems per hill, 1st and 2nd samplings combined.

1964-65

	K_1	K_2		
Units /acre	135	270	Mean	
P_1 90	3.4	3.4	3.4	S E for means ± 0.07
P_2 180	3.5	3.2	3.3	S E for comparisons within table ± 0.09
Mean	3.5	3.3		C V = 13.6%

1965-66

	K_1	K_2		
Units /acre	135	270	Mean	
P_1 90	3.2	3.0	3.1	S E for means ± 0.05
P_2 180	3.1	2.7	2.9	S E for comparisons within table + - 0.07
Mean	3.1	2.9		C V = 7.7%

Main effects of P and K sig. ($P < .05$)

1966-67

	K_1	K_2		
Units /acre	135	270	Mean	
P_1 90	2.09	2.40	2.25	S E for means ± 0.063
P_2 180	2.62	2.12	2.37	S E for comparisons within table ± 0.090
Mean	2.36	2.26		

Interaction of P and K sig. ($P < .05$) C V = 7.8%

The effect of N P K applied to the parent crop on the growth of the progeny at the 2nd sampling.

Table 4.21. The effect of N on weight (g) of D M in stems, leaves and stolons per hill at 2nd sampling.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1964-65	33.1	36.9	29.8	38.0	38.1	± 2.90		22.8
1965-66	36.2	37.7	40.9	41.1	44.9	± 1.95	L. 01	17.1
1966-67	46.4	44.3	47.5	47.1	47.6	± 1.31		11.3

Table 4.22. The effect of N on yield (fresh wt g) tubers per hill at 2nd sampling.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1964-65	1.68	0.79	1.39	2.18	1.08	± 0.541		139.2
1965-66	0.44	0.28	0.33	0.69	1.03	± 0.159	L. 01	111.3
1966-67	77.3	73.7	92.1	103.1	100.6	± 5.61	L. 01	25.1

Table 4.23. The effect of N on number of tubers per hill at the 2nd sampling.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P<	C V %
1964-65	5.8	5.2	5.4	8.1	5.7	± 1.62		84.9
1965-66	6.0	6.0	6.1	6.1	6.9	± 0.93		51.2
1966-67	15.9	14.1	16.4	16.0	16.0	± 0.86		21.9

Table 4.24. The effect of P and K on the number of tubers per hill at the 2nd sampling.

1964-65

Units /acre		K_1 135	K_2 270	Mean
P_1	90	5.9	5.5	5.7
P_2	180	7.7	5.1	6.4
	Mean	6.8	5.3	

S E for means ± 0.62

S E for comparisons within table ± 0.88

C V = 64.7%

1965-66

Units /acre		K_1 135	K_2 270	Mean
P_1	90	8.4	5.8	7.1
P_2	180	5.6	5.1	5.3
	Mean	7.0	5.5	

S E for means ± 0.38

S E for comparisons within table ± 0.54

C V = 38.5%

Main effects of P and K sig ($P < .05$)

1966-67

Units /acre		K_1 135	K_2 270	Mean
P_1	90	16.31	15.59	15.95
P_2	180	17.06	13.79	15.43
	Mean	16.69	14.69	

S E for means ± 0.58

S E for comparisons within table ± 0.82

C V = 10.4%

Main effect of K sig. ($P < .05$)

Table 4.25. The effect of seed tuber size and K on the number of tubers per hill at the 2nd sampling.

1964-65

	K_1	K_2			
Units /acre	135	270	Mean		
T_1 Large seed	9.7	8.6	9.1	S E for means	± 0.62
T_2 Small seed	3.8	1.9	2.9	S E for comparisons within table	± 0.87
Mean	6.8	5.2		C V = 64.7%	

1965-66

	K_1	K_2			
Units /acre	135	270	Mean		
T_1 Large seed	6.4	3.6	5.0	S E for means	± 0.38
T_2 Small seed	7.5	7.4	7.5	S E for comparisons within table	± 0.54
Mean	7.0	5.5		C V = 38.5%	

Main effect of K sig. ($P < .05$)

Interaction of T and K sig. ($P < .05$)

1966-67 not available due to changed experimental design.

The effect of N P K applied to the parent crop on the growth development of tubers at the 3rd sampling.

Table 4.26. The effect of N on total number of tubers per hill at the 3rd sampling.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P <	C V %
1964-65	29.6	25.8	25.9	26.3	28.8	± 1.16	Q .05	19.6
1965-66	30.6	31.5	35.9	34.0	32.6	± 2.04		16.5
1966-67	16.4	15.2	16.7	16.5	16.3	± 0.79		19.6

Table 4.27. The effect of P and K on total number of tubers per hill at the 3rd sampling.

1964-65

Units /acre		K_1 135	K_2 270	Mean		
P_1	90	28.0	26.3	27.1	S E for means	± 0.91
P_2	180	28.8	26.0	27.4	S E for comparisons within table	± 1.20
	Mean	28.4	26.1		C V = 21.0%	

1965-66

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	33.8	34.3	34.0	S E for means	± 1.79
P_2 180	31.0	32.6	31.8	S E for comparisons within table	± 2.53
Mean	32.4	33.4		C V = 34.4%	

1966-67

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	15.28	17.23	16.26	S E for means	± 0.392
P_2 180	17.27	15.05	16.16	S E for comparisons within table	± 0.554
Mean	16.28	16.14		C V = 6.8%	

Interaction of P and K sig. ($P < .01$)

Table 4.28. The effect of N on yield of tubers per hill (g) at 3rd sampling.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	C V %
1964-65	384.9	369.9	342.7	404.7	422.7	± 23.25	24.1
1965-66	548.8	597.3	621.5	622.0	610.5	± 17.52	11.6
1966-67	679.4	657.9	652.6	667.7	666.5	± 19.56	11.7

Table 4.29. The effect of P and K on yield of tubers per hill (g) at 3rd sampling.

1964-65

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	393.7	361.8	377.7	S E for means	± 10.81
P_2 180	390.7	393.7	392.2	S E for comparisons within table	± 15.29
Mean	392.2	377.8		C V = 17.7%	

1965-66

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	599.2	605.9	602.6	S E for means	± 23.61
P_2 180	617.9	577.0	597.4	S E for comparisons within table	± 33.39
Mean	608.6	591.4		C V = 24.8%	

1966-67

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	676.0	701.1	688.5	S E for means	± 10.33
P_2 180	671.3	610.9	641.1	S E for comparisons within table	± 14.61
Mean	673.6	656.0		C V = 4.3%	

Main effect of P sig. ($P < .01$)

Interaction of P and K sig. ($P < .05$)

The effect of N P K applied to the parent crop on the yield and number of tubers at final harvest.

Table 4.30. The effect of N on the total yield of tubers tons per acre at final harvest.

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P <	C V %
1964-65	15.67	14.57	13.74	14.70	14.95	± 0.539	Q.01	11.0
1966-67	22.54	22.21	22.37	22.14	21.43	± 0.474		8.5
2 year mean								

Table 4.31. The effect of P and K on the total yield of tubers tons/acre at final harvest.

1964-65

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	14.52	14.18	14.16	S E for means	± 0.341
P_2 180	15.53	15.05	15.30	S E for comparisons within tables	± 0.482
Mean	14.83	14.62		C V = 14.6%	

1966-67

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	22.97	21.68	22.32	S E for means	± 0.342
P_2 180	22.57	21.34	21.95	S E for comparisons within tables	± 0.484
Mean	22.77	21.51		C V = 4.3%	

Main effect of K sig. ($P < .05$)

Table 4.32. The effect of N on the number of tubers per acre at final harvest. ('000 per acre).

Units /acre N	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P <	C V %
1964-65	198.05	183.35	178.23	187.62	195.50	± 3.375	Q.01	7.2
1966-67	151.43	154.13	154.82	160.87	155.91	± 3.827		9.9
2 year mean								

Table 4.33. The effect of P and K on the number of tubers per acre at final harvest ('000 per acre).

1964-65

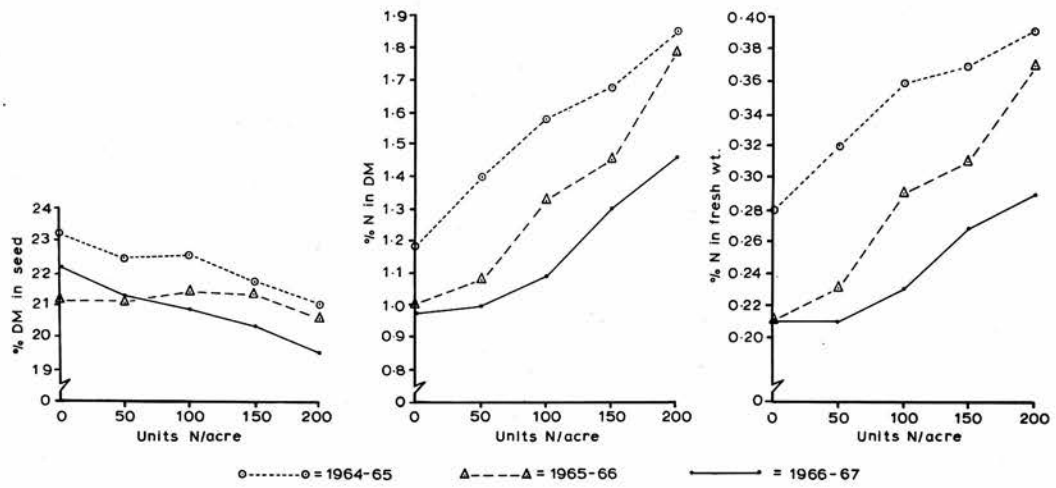
Units /acre	K_1 135	K_2 270	Mean		
P_1 90	181.72	191.89	186.80	S E for means	± 4.225
P_2 180	200.06	180.53	190.30	S E for comparisons within table	± 5.97
Mean	190.89	186.21		C V = 14.1%	

Interaction of P and K sig. (P < .05)

1966-67

Units /acre	K_1 135	K_2 270	Mean		
P_1 90	152.91	159.59	156.25	S E for means	± 3.168
P_2 180	161.51	147.72	154.61	S E for comparisons within table	± 4.480
Mean	157.21	153.65			

Interaction of P and K sig. (P < .05)



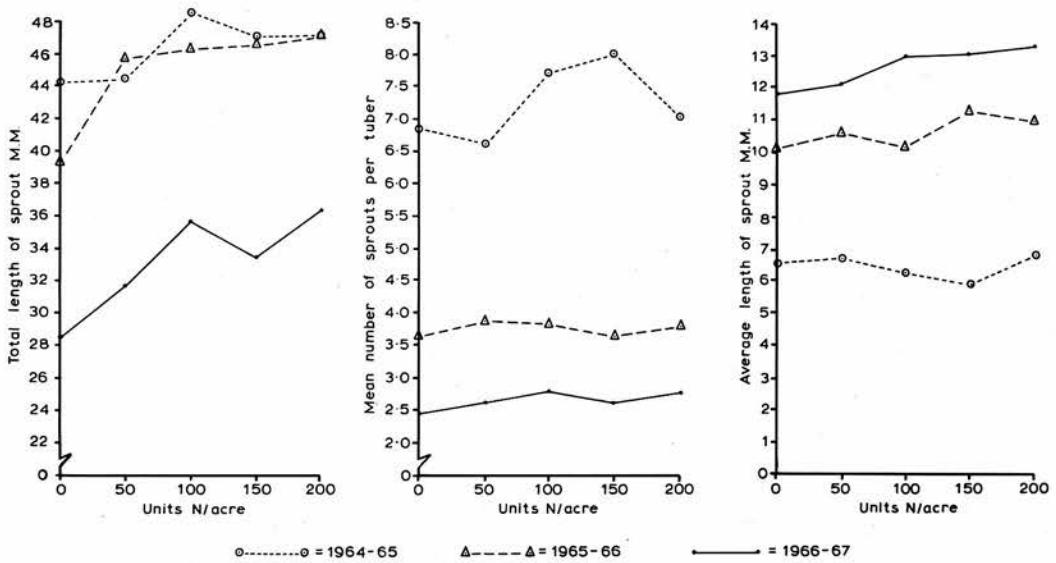
a b c

Fig. 1. The effect of N applied to the parent crop on the tubers produced in respect of:-

a) % Dry Matter of seed.

b) % N in the Dry Matter.

c) % N in the fresh weight.



a b c

Fig. 2. <u>The effect of N applied to the parent crop on the</u> performance of the progeny tubers in respect of:-

a) Total length of sprout per tuber m m.

b) Mean number of sprouts per tuber.

c) Average length of sprouts m m.

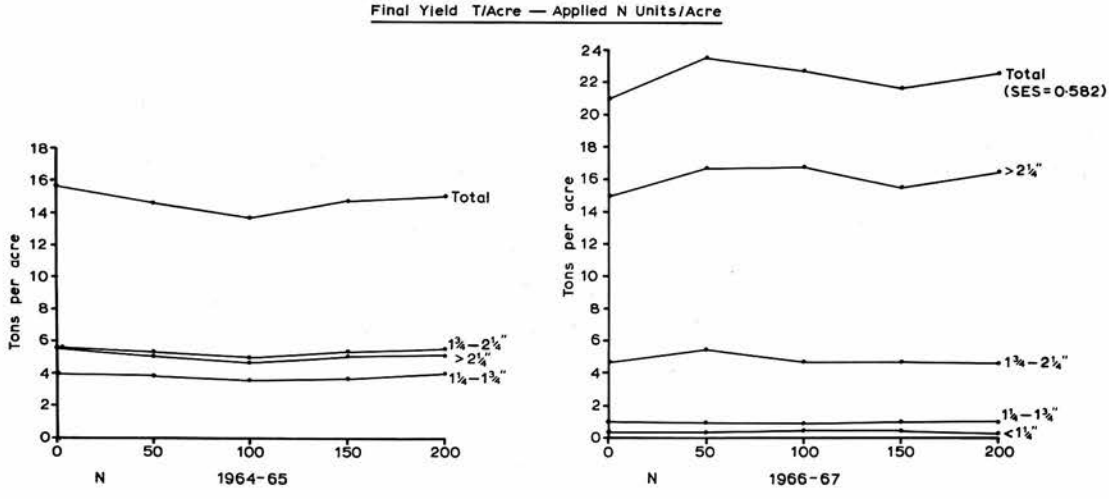


Fig. 3. The effect of N applied to the parent crop on the yield per acre of the crop from the progeny tubers.

CHAPTER 5

Results of Growth Year 1965

Section 5.1. The effect of N P K applied to the Parent crop on the N and D M content of the seed tubers produced.

5.1.1. The effect of N on the % N in D M of seed tubers.

There was a positive linear relationship ($P < 0.01$) between the rate of N applied to the crop and the % N in the dry matter of the tubers (Fig. 1). Neither P nor K influenced the nitrogen content nor did they interact with the nitrogen effect (Table 4.2).

5.1.2. The effect of N on the % D M in the seed tubers.

There was a negative linear relationship ($P < 0.05$) between the rate of N applied to the crop and the dry matter content of the tubers harvested (Fig. 2). Neither P nor K affected the dry matter nor did they interact with N to a degree which reached statistical significance, but tubers produced with K_1 had a D M % of 22.7 and with K_2 21.7 (Table 4.6).

5.1.3. The effect of N on the % N in fresh weight of seed tubers.

Increased N raised the % N in the dry matter but decreased the % dry matter in the tubers to a lesser degree (Fig. 1 & 2).

Therefore N, as a percentage of fresh weight of tubers, increased (Sig $P < 0.01$) with each additional increment of N. Neither P nor K had a significant effect (Table 2.4).

Section 5.2. The effect of N P K applied to the mother crop on the sprouting of the progeny tubers.

5.2.1. The effect of N on the number of sprouts per tuber.

Nitrogen had no significant effect on the number of sprouts per tuber at the time of planting although the 0 and 50 units of N per acre produced fewer sprouts than higher levels. This trend was seen in all three years (Table 4.7). The higher level of P produced more sprouts than the lower level (Sig $P < 0.05$) (Table 4.8). The higher level of K produced fewer sprouts than the lower but the difference was non-significant. This effect was seen in subsequent years.

5.2.2. The effect of N P K on the total length of sprout per tuber.

The 0 and 50 units /acre N produced a shorter total length of sprout than higher levels, but the effect was non-significant (Table 4.9). P and K had no effect.

5.2.3. The effect of N P K on the mean length of sprout.

The levels of N P K did not affect the mean length of sprouts (Table 4.11 and 4.12).

Section 5.3. The effect of N P K applied to the mother crop on the growth of the progeny at the first sampling.

The first sampling took place 4½ weeks after planting.

5.3.1. The effect of N P and K on:-

The weight of dry matter in leaves, stems and stolons.

5.3.2. The weight of dry matter in the roots.

The levels of N P K produced no effect on the weight of dry matter in the leaves and stems (Table 4.15), or in the roots (Table 4. 16).

1st and 2nd Sampling 1965.

5.4.1. The effect of N P K applied to the mother crop on the number of mainstems per hill in the progeny crop (combined results from 1st and 2nd samplings).

The level of N P K did not affect the number of mainstems per hill significantly (Table 4.19). There was a trend repeated in the other two years for the combination of the highest levels of P and K to depress the number of mainstems in relation to the other combinations. (Table 4.20).

The interaction between tuber size and K was significant ($P < 0.05$) (Table 5.4.1). The high level of K depressed the number of mainstems per hill from the large tubers but not from the small.

Table 5.4.1. The effect of tuber size and K on the number of main-stems per plant (combined 1st and 2nd sampling).

Tuber size		Units K_2 O/acre 135	270
T_1	Large	4.4	4.0
T_2	Small	2.5	2.6

S E ± 0.098

5.5. The effect of N P K applied to the parent crop on the growth of the progeny at the 2nd sampling.

The second sampling took place 7 weeks after planting.

The effect of N P K on :-

5.5.1. The weight of D M in the stems, leaves and stolons (Table 4.21).

2. The weight of D M in the roots.

3. The yield of tubers (Table 4.22).

4. The number of tubers (Table 4.23 and 4.24).

The rates of N P K applied to the parent crop had no effect on these variates. The only points of note were that 50 units N/acre produced the lowest yield of tubers but an average number of tubers per hill and 100 units N/acre applied to the parent crop produced the least foliage and 200 units N the most.

5.6. The effect of N P K applied to the mother crop on the growth of the progeny at the 3rd sampling.

The third sampling took place 12 weeks after planting.

5.6.1. The effect of N P K on the number of tubers per plant, 3rd sampling.

The quadratic effect of N was significant ($P < 0.05$), 50 units /acre of N applied to the mother crop produced fewer tubers per plant than all the other treatments (Table 2.26). Growth in this treatment was otherwise normal in terms of foliage and mainstems at the earlier samplings. The levels of P and K had no effect (Table 4.27).

5.6.2. The effect of N P K on the yield of tubers - 3rd sampling.

The levels of N P K had no effect on the yield of tubers at the 3rd sampling (Tables 4.28 and 4.29).

5.7. The effect of N P K applied to the parent crop on the yield and number of tubers from the progeny at final harvest.

5.7.1. The effect of N on the number of tubers per acre at final harvest.

The quadratic effect of N was significant ($P < 0.01$), as it had been at the 3rd sampling (Table 4.32). The 100 units of N per acre treatment depressed the number of tubers per acre significantly below the number from the nil and 200 units /acre . However the linear interaction between tuber size and N was significant at $P < 0.01$ (Table 5.7.1).

Table 5.7.1. The effect of tuber size and N on the number of tubers per acre ('000 s) at final harvest.

		N_o	N_1	N_2	N_3	N_4
Units N/ac		0	50	100	150	200
Seed size						
T_1	Large	215.7	202.5	202.1	211.7	231.2
T_2	Small	180.4	164.1	154.3	163.5	159.7

S E for comparisons within table ± 6.42

With large tubers there was a slight depression of tuber numbers between nil N and 100 units N but a large increase between 100 units and 200 units which latter outnumbered all other treatments giving a positive linear trend, whereas with small tubers the quadratic relationship held, with equal numbers from nil or 200 units N per acre on the parent crop, and lower numbers with N_1, N_2 and N_3. At the earlier sampling (3rd), this interaction was not present, the quadratic trend was present at both tuber sizes. Estimates of the incidence of Blackleg at the first and second sampling may explain these results, the incidence was lowest in the 200 units N plots, succeeded by the nil nitrogen plots (Table 5.7.1b).

Table 5.7.1b. The percentage of plants showing severe symptoms of Blackleg at 1st and 2nd sampling.

	N_o	N_1	N_2	N_3	N_4
Rate of N units /acre	0	50	100	150	200
	5	6.25	10	7.5	2.5

Later estimates were not made, but the outbreak progressed and the relative proportions could be expected to be maintained. The effect of high N in reducing tuber infection agrees with the findings of Graham and Harper (1966).

Against the attribution of the decline in tuber numbers at intermediate rates of N to Blackleg infection is the existence of the quadratic effect ($P<0.05$) at the previous sampling (3rd), where plants obviously suffering from Blackleg were rejected from the sample. However plants just developing the disease could have been included, which may have been reflected in yield.

The main effects of P and K were not significant but the interaction was ($P<0.05$) (Table 4.33). Increasing the rate of K in combination with the high rate of P had the effect of reducing the number of tubers, whereas at the low rate of P there was no effect. The higher rate of P in combination with a low rate of K increased the number of tubers compared with the lower P rate. The higher rate of P had also given increased sprout numbers.

5.7.2. The effect of N P K on the total yield of tubers at final harvest.

The positive quadratic effect of N on yield was significant $P< 0.01$ (Table 4.30). This followed the same pattern as tuber numbers (Table 4.32), the lowest yield was from 100 units N/acre and the highest from nil N on the parent crop. As was

argued with tuber numbers, the incidence of Blackleg makes the validity of interpreting effects suspect. The levels of P and K did not affect yield (Table 4.31).

5.7.3. The effect of N on the yield of tubers $>2\frac{1}{4}$, $1\frac{1}{4}$ - $2\frac{1}{4}$", $<1\frac{1}{4}$".

The quadratic effect of N on the yield of $1\frac{1}{4}$ - $2\frac{1}{4}$" grade tubers was significant ($P<0.05$) (Table 5.7.3). The yield from nil N and 200 units N/acre was significantly greater than from 100 units /acre.

The T N linear interaction was significant ($P<0.05$) for the same grade (Table 5.7.3).

Table 5.7.3. The effect of seed tuber size and N on the final yield of $1\frac{1}{4}$" - $2\frac{1}{4}$" grade tubers. Tons /acre.

		N_0	N_1	N_2	N_3	N_4
Units N/ac		0	50	100	150	200
Seed size						
T_1	Large	10.40	10.16	9.25	9.92	11.08
T_2	Small	8.98	8.26	7.67	8.03	7.92
Mean		9.69	9.21	8.46	8.97	9.50

S E for means of N $\pm$ 0.270

S E for horizontal comparisons within table $\pm$ 0.312

This grade accounted for most of the curvilinear effect seen in the total yield.

The treatments had no effect on the yield of grades $>2\frac{1}{4}$" or $<1\frac{1}{4}$".

Summary of Results - 1965 - Growth year

Increasing rates of N applied to the parent crop raised the % N in the dry matter and in the fresh weight of seed tubers produced but lowered the dry matter content (Fig. 1, 2 and 3). There was a tendency for the high level of K to reduce the dry matter content but otherwise P and K had no effect.

The number of sprouts and the total length of sprout per tuber were not affected significantly by N but N_0 and N_1 produced fewest sprouts, and the shortest total length (Tables 4.7 and 4.9). The mean length of sprout was unaffected by N. The higher level of K reduced sprout number and the higher level of P increased sprout number ($P < 0.05$) (Table 4.8).

Foliage growth as expressed by the weight of dry matter in stems and leaves was unaffected by the level of N applied to the parent crop although N_0 produced the least growth 4½ weeks after planting (Table 4.15) and the second lowest 7 weeks after planting when tuber initiation had just started. The 100 units N/acre treatment produced the smallest haulm growth at the latter stage and 200 units the most (Table 4.21). The levels of P and K exerted no influence.

Root growth was unaffected by N P or K.

The number of mainstems per hill (1st and 2nd sampling combined) was not affected by the N or P level but P_2 K_2 tended to reduce the number. The main effect of K was not significant but in the plants from large seed the high level of K reduced the mainstem number ($P < 0.05$) (Table 4.20).

The number of tubers per hill was not affected by N at the sampling 4½ weeks after planting during the time of initiation, but 12 weeks after planting the number of tubers on the 50 and 100 units N/acre treatment was low, (quadratic effect sig $P<0.05$) and the greatest numbers were from the nil N and 200 units N/acre treatments (Table 4.26). A possible reason for this is discussed in the next paragraph. The K_2 treatment produced fewer tubers than K_1 (Table 4.27). The lower sprout numbers with K_2, and the fewer mainstems at K_2 level with large seed offers some explanation of this (Table 4.20).

The yield of tubers (fresh weight) 7 weeks after planting was not affected by N, P or K but the 50 units N/acre treatment produced the lowest yield (Table 4.22) and 100 units N/acre the lowest yield 12 weeks after planting (Table 4.28). This depression of yield at 100 units N and to a lesser extent at 50 units N continued until final harvest (quadratic effect sig $P<0.01$). It is suggested that the low yield from these plots and the high yield from the nil N and 200 units N is related to infection with Blackleg which infected the crop in general. (This was discussed in Section 5.7). The low yield from these treatments at the 4½ and 7 week samplings may have been due to infection not manifest in gross symptoms. The plants in the samples taken at these times were contiguous to plants showing frank infection and on present knowledge of the disease were probably infected. Thus doubt must be cast on the validity of interpreting this year's results for 3rd and final harvest.

CHAPTER 6

Results of Growth Year 1966

6.1. The effect of N P K applied to the parent crop on the N and D M content of the seed tubers produced.

6.1.1. The effect of N P K on the % N in the D M of seed tubers.

As in the previous year there was a positive linear relationship between N treatments and the percentage N in the dry matter ($P<.01$, Fig.1). There did not appear to be an interaction between N P or N K although this would not have been readily discerned, since only one bulk sample of each N P K treatment was available for analysis this year. No separate analysis of large and small tubers was made this year.

6.1.2. The effect of N P K on the % D M of seed tubers.

The effect of N treatment on the dry matter percentage was not significant (Fig.1). The higher rate of K reduced dry matter percentage as in the previous year (Table 4.6).

6.1.3. The effect of N P K on the % N in fresh weight of seed tubers.

The % N in the fresh weight of the seed tubers was increased by each increment of applied N (Fig.1).

6.2. The effect of N P K applied to the parent crop on the sprouting of the progeny tubers.

6.2.1. The effect of N P K on the number of sprouts per tuber.

There was no significant effect of N on the number of sprouts per tuber, although the nil treatment was exceeded by all treatments other than 150 units N/acre, which it equalled (Table 4.7). The lower rate of K produced a greater number of sprouts per tuber than did the higher rate (sig $P<.05$) (Table 4.8). This is consistent with the previous year's results. The lower rate of P (90 units P_2O_5 /acre) produced a greater number of sprouts than did the higher rate (sig $P<0.05$). This is the opposite result from the previous year.

The reduction with increased P was much less (not significent) at the K_1, than at the K_2 level (PK interaction significant $P<0.05$). The P_2 K_2 combination produced significantly fewer sprouts than the other combinations of P and K ($P_2K_2 < P_1K_1$, P_2K_1, P_1K_2).

The effect of P was influenced by the level of N (Table 6.2.1a) (P N linear residual interaction sig $P<0.05$).

Table 6.2.1a. The effect of N and P on the number of sprouts per tuber.

		N_0	N_1	N_2	N_3	N_4
Units /acre N		0	50	100	150	200
P_1	90	3.96	4.10	3.99	3.99	3.79
P_2	180	3.24	3.67	3.64	3.23	3.78

S E for vertical comparisons ± 0.113
S E for horizontal comparisons ± 0.116

P_1 exceeds P_2 to a varying degree at different levels of N; and at N_2 and N_4, did not differ significantly. The effect of the level of P in combination with K_1 depends on the level of N (N P K interaction sig $P<0.05$) (Table 6.2.1b).

Table 6.2.1b. The effect of N P K on the number of sprouts per tuber.

		K_1	K_2
N_o	P_1	3.86	4.07
	P_2	3.98	2.50
N_1	P_1	3.91	4.28
	P_2	4.03	3.32
N_2	P_1	4.02	2.96
	P_2	3.65	3.63
N_3	P_1	4.10	3.88
	P_2	3.79	2.66
N_4	P_1	3.94	3.63
	P_2	4.00	3.57

S E $\pm$ 0.160

The effect of P was such that sprout numbers per tuber at $P_2 K_2 < P_1 K_2$ at all levels of N, but $P_2 K_1$ was less than $P_1 K_1$ only at N_2 and N_3. Similarly with regard to K, $P_2 K_2 < P_2 K_1$ at all levels of N but $P_1 K_2$ was less than $P_1 K_1$ only at N_2, N_3 and N_4. $P_1 K_1$ exceeded $P_2 K_2$ at all levels of N. Thus the depressive effect on sprout numbers of a high level of P or K was slight and erratic where the combination was with the lower level of the other.

6.2.2. The effect of N P K on the total length of sprout per tuber.

The total length of sprout was increased with increasing N (N linear sig $P < 0.05$) (Table 4.9).

The greatest response was to the first increment of 50 units N/acre with small but regular responses to further increments. At the lower level of P there was a decline between N_3 and N_4 (P N linear sig $P < 0.05$) (Table 6.2.2).

Table 6.2.2. The effect of N and P on the total length of sprout per tuber.

		N_0	N_1	N_2	N_3	N_4
Units /acre N		0	50	100	150	200
P_1	90	40.97	47.63	46.10	47.28	42.40
P_2	180	37.60	44.13	46.25	46.00	52.05

S E for vertical and horizontal comparisons within table ± 2.951

The shorter total length of sprout at N_4 P_1 than at other levels of N at P_1, is in part a reflection of the number of sprouts, which also tends to be low at N_4 P_1 (Table 6.2.1) as compared N_0 - N_3 at P_1.

However, sprout numbers at N_4 P_1 are equal to N_4 P_2 but the total length of sprouts is much greater at P_2 than P_1 with N_4. The effect of an increase in K was to reduce the total length of sprout. (Sprout numbers were affected in the same way by K).

6.2.3. The effect of N P K on the mean length of sprout.

Increasing the N applications to the parent crop tended to increase the mean length of sprout, but the effect did not quite attain statistical significance at 5%. Neither P nor K affected the mean length of sprout.

6.3.1. The effect of N P K applied to the parent crop on the emergence of the progeny.

Emergence counts were made when nearly 75% of the plants had emerged. All plots eventually reached 100% emergence. The positive linear effect of N was significant ($P < 0.01$), nil N plots emerged more slowly than those receiving N but differed significantly only from the 200 units N/acre treatment. (Table 4.13). Emergence was slower on the high P plots than on the lower level plots (sig $P < 0.05$) (Table 4.14). The P K interaction was significant ($P < 0.01$), P_1 exceeded P_2 only in combination K_2, at the K_1 level the emergence was equal. More plants had emerged on the K_2 treatments than on the K_1 plots at the P_1 level but at P_2 the opposite held, $P_2 K_2 < P_2 K_1$. Thus emergence was not related to mean sprout length as closely as it was to sprout number and total length of sprout per tuber.

1st Sampling 1965 - 66

6.4. The effect of N P K applied to the parent crop on the growth of the progeny at the first sampling.

The first sampling took place 5½ weeks after planting.

6.4.1. The weight of dry matter in stems and leaves (Table 4.15).

6.4.2. The weight of dry matter in the roots (Table 4.16).

There was no significant effect of N P K on the weight of dry matter in either stems and leaves or roots although N_4 produced the greatest quantity of stems and leaves and P_2 K_2 tended to reduce foliage growth, (as it had depressed the number of sprouts).

6.5. The effect of N P K applied to the parent crop on the number of mainstems per plant in the progeny crop - combined results from 1st and 2nd sampling.

6.5.1. The effect of N P K on the number of mainstems.

The rate of N application had no effect on the number of mainstems (Table 4.19). An increase in the level of P from 100 units /acre P_2 0_5 to 200 units depressed the number of mainstems per plant from 3.1 to 2.9 (Sig $P < 0.05$ almost < 0.01). This effect was seen only in the larger tubers (Table 6.5.1), and the tuber size, potash interaction was significant at $P < 0.05$.

Table 6.5.1. The effect of tuber size and potash on the number of mainstems

	Units K_2 0/acre	
Tuber size	135	270
Large	3.66	3.22
Small	2.62	2.56
Standard error	± 0.09	

This interaction had been found in the previous year (Table 4.4.1a). The P K interaction was not significant but the trend was, as in the previous year, for the combination of high rates of P and K to depress the number of mainstems as compared with the other three combinations (Table 4.20).

1965 Second sampling.

6.6. The effect of N P K applied to the parent crop on the growth of the progeny crop at the second sampling.

The second sampling took place 7½ weeks after planting.

6.6.1. The effect of N P K on the weight of D M in the leaves and stems.

Increasing rates of N applied to the parent crop had a positive linear effect ($P < 0.01$) on the weight of dry matter in the leaves and stems at the second sampling (Table 4.21). Neither P nor K, nor their interaction with N affected the weight of foliage.

6.6.2. The effect of N P K on the weight of D M in the roots.

The rate of N P K had no effect on the weight of dry matter in the roots.

6.6.3. The effect of N P K on the number of tubers.

The rate of N had no effect on the number of tubers initiated at the second sampling, although 200 units N/acre outnumbered all other N treatments by a small margin (Table 4.23).

The higher level of both P and K depressed the number of tuber initiated at the second sampling $P < 0.05$ (Table 4.24) In the previous year K_2 had the same effect whereas P_2 had increased the number of tubers; neither effects were significant in 1965. The K_2 treatment depressed tuber numbers only in case of the large seed (T K interaction sig $P < 0.05$) (Table 4.25). This relationship also held for mainstem numbers (Table 6.1.1). It was noticable that the large seed produced fewer tubers than the small. This result is anomalous and was not seen in the previous year, nor was it at the third sampling.

In other ways the large seed behaved normally and produced more mainstems, a greater weight of foliage and a greater weight of tubers than did small seed.

The T P K interaction was also significant $P < 0.05$ (Table 6.6.3a).

In the small tubers, K_2 increased the number of tubers only in combination with P_1. In all other cases the main effect of a depression with increased K was found. T_1 P_2 K_1 was low in yield.

Table 6.6.3a. The effect of tuber size, P and K on the number of tubers per hill at the 2nd sampling.

		P_1		P_2	
		K_1	K_2	K_1	K_2
T_1	Large seed	8.8	3.5	4.0	3.6
T_2	Small seed	8.0	8.2	7.0	6.5

S E ± 0.76

An explanation of the interaction was sought in terms of number of mainstems, weight of D M in foliage, and weight of D M per mainstem.

The number of mainstems from the T_2 P_1 K_2 treatments was slightly greater than from T_2 P_1 K_1 and although the difference was slight may have accounted for the effect (Table 6.6.3b).

Table 6.6.3b. The effect of tuber size, P and K on the number of mainstems per hill at the 2nd sampling.

	P_1		P_2	
	K_1	K_2	K_1	K_2
Large seed	3.64	3.38	3.54	2.88
Small seed	2.50	2.62	2.62	2.48

S E ± 0.160

Against this both T_2 P_1 K_2 and T_2 P_2 K_1 have 2.62 mainstems per plant but have produced 8.2 and 7.0 tubers per plant respectively. A comparison of tuber numbers between large and small seed at the same level of P and K shows that apart from P_1 K_1, small seed produced a greater number of tubers than did large.

When mainstem numbers are compared at the same P K level large seed produce more than small, likewise with total weight of foliage (Table 6.6.3c); thus differences in tuber numbers cannot be explained in terms of mainstem numbers or weight of foliage, see also Table 6.6.3e.

Table 6.6.3c. The effect of tuber size, P and K on the weight of D M leaves and stems per hill at the 2nd sampling.

	P_1		P_2	
	K_1	K_2	K_1	K_2
Large seed	49.4	43.2	48.7	47.6
Small seed	33.8	34.7	32.9	31.1
	S E ±	1.55		

It was possible that the size of each mainstem could control the earliness of tuber initiation (Table 6.6.3d). There is a remarkable lack of variation in these apart from T_1 P_1 K_2 and no explanation of the number of tubers per plant is apparent.

Table 6.6.3d. The effect of tuber size, P and K on the weight D M per mainstem at the 2nd sampling.

		P_1		P_2	
		K_1	K_2	K_1	K_2
T_1	Large seed	13.57	12.78	13.75	16.52
T_2	Small seed	13.50	13.24	12.55	12.54

But mean weight of mainstem and mainstem numbers will be related, and may both control tuber numbers initiated, so it is possible that the number of tubers per mainstem may be related to the size of mainstem (eliminating number of mainstems).

Table 6.6.3e. The effect of tuber size, P and K on the number of tubers per mainstem.

	P_1		P_2	
	K_1	K_2	K_1	K_2
T_1	2.417	1.035	1.129	1.250
T_2	3.200	3.129	2.671	2.621

Comparing Tables 6.6.3d and e no effect is apparent. If number of mainstems is the controlling factor, the number of tubers per mainstem would be constant, in fact the differences between treatments are proportionately greater than on a "per hill" basis.

6.6.4. The effect of N P K on the yield of tubers at the 2nd sampling.

There was a positive linear relationship (Sig $P < 0.01$) (Table 4.22) between increasing nitrogen levels applied to the parent crop and the fresh weight of tubers of the progeny crop at the second sampling. Neither P nor K affected the yield significantly, but the K N linear and quadratic interactions were significant ($P < 0.05$) (Table 6.6.4).

The effect of N was linear only at the low level of K, at the higher level of K the effect was linear up to 150 units N/acre, then the yield fell at 200 units N/acre. The major difference between the yield at N_4 from the different levels of K gives rise to the interaction.

Table 6.6.4. The effect of K and N on the yield (g) of tubers per hill at the 2nd sampling.

		N_0	N_1	N_2	N_3	N_4
Units /acre		0	50	100	150	200
K_1	135	0.42	0.31	0.20	0.64	1.65
K_2	270	0.46	0.24	0.45	0.75	0.40

S E for horizontal comparisons $\pm$ 0.225

S E for vertical comparisons $\pm$ 0.241

The number of tubers initiated on the N_4 K_2 treatments also tended to be low (Table 6.6.4), but on the other hand N_3 K_1 had similar tuber numbers and gave a relatively high yield; N_1 K_1 produced almost as many tubers as N_4 K_1 but only one fifth the yield. Thus the correlation between tuber numbers and yield is low at this early stage of development, as might be expected.

An examination of the number of mainstems at the 2nd sampling, shows that the number of mainstems with N_4 K_2 was low as compared with N_4 K_1, and may account for part of the effect.

Sprouting, emergence and foliage at 1st sampling on N_4 K_2 was similar to that on the N_4 K_1 treatment, and the linear trend in growth of leaves and stems at the 2nd sampling held at both levels of K, although at K_1 the K_1 N_4 plants showed growth well above the previous level of K_1 N_3, and at K_2 the K_2 N_4 plots equalled K_2 N_3.

The low yield of N_4 K_1 as compared with N_4 K_2, was also observed at the next sampling (3rd) although the K N linear interaction was not significant.

The number of tubers was also low on this treatment at the 3rd sampling (Table 5.7.1) and the K N linear interaction was significant.

In the previous year K_2 exceeded K_1 in yield at N_4; the opposite effect.

6.7. The effect of N P K applied to the parent crop on the growth of the progeny crop at the third sampling.

The third sampling took place 12 weeks after planting.

6.7.1. The effect of N P K on the number of tubers per plant.

None of the main effects of N P or K was significant in determining the number of tubers per plant (Tables 4.23 and 4.24). The K N linear and T K N quadratic interactions were significant at $P < 0.01$. At levels of N, 0, 50 and 100 units /acre, $K_1 < K_2$, but at 150 and 200 units N/acre $K_1 > K_2$

(Table 6.7.1a); however none of these differences was significant.

This is the reverse of the finding at the previous sampling where $K_1 > K_2$ at all N levels <u>other</u> than 200 units.

Table 6.7.1a. <u>The effect of K and N on the number of tubers per hill at the 3rd sampling.</u>

		N_o	N_1	N_2	N_3	N_4	
Units	/acre	0	50	100	150	200	Mean
K	135	28.8	28.7	34.3	34.3	35.8	32.4
K_2	270	32.5	34.2	37.4	33.7	29.3	33.4
Mean		30.6	31.5	35.9	34.0	32.6	

S E for N ± 2.04

S E for K ± 1.79

S E for vertical comparisons within table ± 3.14

S E for horizontal comparisons within table ± 2.89

At K_1 level, increasing N increases the number of tubers, whereas at K_2 increasing N raises tuber numbers to a maximum at 100 N, and further increments reduce tuber numbers. Mainstem numbers (1st and 2nd sampling combined) and foliage D M at 2nd sampling do not provide a reason for the decline with K_2 N_3 and K_2 N_4, and since these variates were not measured at the 3rd sampling no explanation can be offered.

Table 6.7.1b. The effect of tuber size, K and N on number of tubers per hill, 3rd Sampling.

		T_1 Large Tubers				T_2 Small Tubers		
		K_1 135	K_2 270	Mean		K_1 135	K_2 270	Mean
N_o	0	33.6	28.5	31.0	N_o 0	24.0	36.4	30.2
N_1	50	28.1	34.8	31.4	N_1 50	29.3	33.7	31.5
N_2	100	29.0	36.6	32.8	N_2 100	39.7	38.2	39.0
N_3	150	37.0	40.0	38.5	N_3 150	31.7	27.4	29.5
N_4	200	40.3	31.0	35.7	N_4 200	31.3	27.8	29.5
Mean for tuber size		33.9			Mean for tuber size		31.9	

S E for means of N $\pm$ 1.92

S E for means of tuber size $\pm$ 1.79

S E for comparisons within table $\pm$ 5.7

The T K N table (6.7.1b) shows that $K_1 > K_2$, where large seed tubers are planted at nil N and 200 units (not at 150 units), whereas with small seed tubers $K_1 > K_2$ at 100, 150 and 200 units. The linear effect of N at K_1 in the K N table is seen as the resultant of opposing quadratic effects at T_1 K_1 and T_2 K_1. It is only possible to conclude that tuber size and K affect the influence of N level in the parent crop on the production of numbers of tubers at a late stage of growth in the progeny crop.

The T N interaction was significant($P < 0.05$); plants from large seed tubers produced more tubers at 3rd sampling than plants from small tubers except at N_2. The T K N table shows this was due to a very high number of tubers from T_2 N_2 K_2 and T_2 N_2 K_1. This treatment had initiated less than an average number at the previous sampling and did not show any distinguishing feature at the 2nd sampling in terms of foliage growth or mainstem number (1st and 2nd sample combined).

The P N linear interaction is significant($P < 0.05$) (Table 6.7.1c).

Table 6.7.1c. The effect of P and N on the number of tubers per hill at the 3rd sampling.

		N_o	N_1	N_2	N_3	N_4	
Units /acre N		0	50	100	150	200	Mean
P_1	90	30.2	32.8	32.8	37.3	37.0	34.0
P_2	180	31.1	30.2	38.9	30.7	28.2	31.8

S E for vertical comparisons ± 3.14

S E for horizontal comparisons ± 2.84

As with the K N interaction it is evident that increasing N at P_1 level increases tuber numbers, but at P_2 there is no response other than at 100 units N/acre. This arises largely from one plot T_2 P_2 K_2 N_2 which produced 56.6 tubers per hill.

6.7.2. The effect of N P K on the yield of tubers at the 3rd sampling.

The positive linear effect of N on tuber yield (Table 4.28) seen at the second sampling was present but did not reach significance at the 5% level of probability. Most of the linear effect lay in the low yield from nil N as compared with all other treatments. Neither P nor K affected the fresh weight yield of tubers and no interactions were significant.

Summary of Results.

1965-66

The % N in the dry matter, and in the fresh weight of seed tubers, were increased by increasing applications of N to the parent crop (Fig. 1). Nitrogen increase reduced the dry matter content of the tubers produced, but the effect was not significant (Fig. 1). High K tended to reduce D M % as in the previous year (Table 4.6).

When these tubers were sprouted prior to planting in the following year, the number of sprouts per tuber was not influenced by the N level, other than that nil N (Table 4.7) (Fig. 2), as in the previous year, produced fewer sprouts than all others except 150 units N/acre, which it equalled. The main effect of K, as in the previous year, was to depress sprout numbers at the higher level ($P < 0.05$) (Table 4.8), and P_2 in contradiction of the previous year, had the same depressive effect.

High P depressed sprout numbers as compared with the lower P rate, where they were both combined with K_2, and the effect was unaffected by the level of N. The relationship of K_2 K_1, in combination with P_2 was similarly unaffected by N. However, where the combination was with the lower level of the other, both P_2 and K_2 had a variable effect on sprout numbers, related to N level. P_1 K_1 produced more sprouts than P_2 K_2 at all levels of N.

Increasing N increased the total length of sprout per tuber (N linear sig $P<0.05$) (Table 4.9) other than that at P_1, where the final increment markedly reduced length. K_2 tended to reduce total sprout length as compared with K_1. Both of these effects were broadly related to sprout numbers.

The mean length of sprout tended to increase with increasing N (Table 4.11). (Fig. 2).

Emergence at a point of time during emergence (75% emergence on average) was increased by N (N linear sig $P<0.01$) (Table 4.13). High levels of P and K combined reduced the emergence rate (Table 4.14).

Foliage growth as expressed by the weight of dry matter in stems and leaves was greatest on the high N treatment and low on nil N 5½ weeks after planting (Table 4.15), and 7½ weeks after planting increasing N increased foliage (N linear sig $P<0.01$) (Table 4.21), this trend was present in the previous year. P_2 K_2 tended to reduce foliage at the first sampling (Table 4.16), but not at the second.

Mainstem numbers were unaffected by N rates. The number of mainstems, similarly to the number of sprouts, was depressed by high rates of P and K (Table 4.20), but in the case of K the depression was seen only in the large seed tuber plants (Table 6.6.3b). The tendency was for P_2 K_2 to depress mainstem numbers more than P_1 K_2 or P_2 K_1. These effects of P, K, and the tuber size K interaction were evident in the previous year.

The number of tubers per plant 7½ weeks after planting was unaffected by N, although 200 units N/acre outnumbered all other treatments by a small margin (Table 4.23), thus the foliage at that sampling which increased with N, did not affect tuber numbers (Table 4.21). It should be noted however that 5½ weeks after planting the greatest growth of foliage was on the 200 units N/acre treatment (Table 4.15), which may have affected the earliness or rate of tuber initiation, a tentative conclusion relevant in considering the 1967 result.

At the sampling 12 weeks after planting the relationship between tuber numbers and seed tuber size, K and N was complex; with K_1, increasing N increased tuber numbers, but not with K_2 (Table 6.7.1a). When tuber size is also considered (Table 6.7.1b) this relationship breaks down and no explanation of these effects can be offered in terms of mainstem numbers or foliage growth. With P_1, increasing N increased tuber numbers but not with P_2.

The yield of tubers 7 weeks after planting increased with increasing N ($P < 0.01$) (Table 4.22), as did foliage. The linear effect of N on yield was present with K_1 but at the K_2 level, the N_4 treatment gave a low yield. The mainstem number on the N_4 K_2 treatment was also low and may offer an explanation.

CHAPTER 7

Results of Growth Year 1967

7.1. The effect of N P K on the N and D M content of potato seed tubers.

7.1.1. The effect of N P K on % N in the D M of tubers.

As in the previous years, increasing the nitrogen in the parent crop increased the % N in the D M of tubers (N linear effect sig $P < 0.01$) (Fig. 1). The rate of increase was greater between 100 and 150 units N/acre than between the two previous increments and the one successive increment (N quadratic effect sig $P < 0.01$).

An increase in K raised the % N in the D M slightly (Sig $P < 0.01$) (Table 4.2); P had no effect. The effect of K_2 exceeded that of K_1 only in combination with P_2 (K P interaction sig $P < 0.01$) ($P_2 K_2 > P_1 K_1$, $P_1 K_2 > P_2 K_1$), and the response to increased P was negative in combination with K_1 and was reversed in combination with K_2. $P_2 K_2$ exceeded all other treatments in the effect of raising the % N in the D M.

7.1.2. The effect of N P K on D M content of tubers.

Increasing N reduced the dry matter content of the seed tubers (N linear effect sig $P < 0.01$) (Fig. 1). The range between the extremes was slightly greater than in previous years.

The higher rate of K depressed the dry matter percentage as compared with the lower rate ($P < 0.01$) (Table 4.6). (Fig. 1). None of the interactions was significant.

7.1.3. <u>The effect of N P K on % N in fresh weight of tubers</u>.

As in previous years, the rate of increase in percentage N in the dry matter with increasing rates of applied N was greater than the fall in percentage dry matter, and the positive linear effect of N in the % N in the fresh weight of tuber was significant $P < 0.01$ (Fig. 1). The rate of increase in N content was greater at higher rates of N application than with the lower (N quadratic sig $P < 0.01$). The first increment had no effect.

The P N quadratic interaction was significant ($P < 0.05$), (Table 7.1.3), whereas with 0, 50 and 200 units N/acre, P_1 was greater than P_2, in combination with 100 and 150 units of N P_1 was less than P_2.

Table 7.1.3. The effect of P and N on the % N in the fresh weight of seed tubers.

		N_o	N_1	N_2	N_3	N_4
Units /acre N		0	50	100	150	200
P_1	90	0.23	0.22	0.22	0.26	0.29
P_2	180	0.20	0.21	0.23	0.27	0.28

S E for vertical comparisons ± 0.007

S E for horizontal comparisons ± 0.007

Interaction of P and N sig ($P < .05$)

There was a depression in nitrogen content at P_1 N_1 and P_1 N_2 as compared with P_1 N_o.

The rate of P and K application did not affect the percentage N in the fresh weight of tuber, but the P K interaction was significant ($P < 0.01$) (Table 4.4), P_1 K_1, P_2 K_2 > P_1 K_2, P_2 K_1. The N content in the fresh weight was greatest where the P_2 O_5 : K_2 O ratio was 1 : 1½, (P_1 with K_1 or P_2 with K_2), even at twice the normal rates of application (P_2 K_2).

7.2. The effect of N P K treatment of the parent crop 1966 on the sprouting of the progeny tubers 1967.

7.2.1. The effect of N P K on the number of sprouts per tuber.

The trend towards an increased number of sprouts from increasing N treatments, observed in the first two years, attained statistical significance (sig $P < 0.05$) in the third year (Table 4.7). (Fig. 2).

There was, however, an interaction with K which is discussed at the end of this section. As in both previous years the number of sprouts per tuber from K_1 exceeded the number from K_2 (sig $P < 0.01$) (Table 4.8). On the other hand the higher rate of P produced more sprouts than the lower rate (sig $P < 0.01$), similar to the first year but opposed to the second year's findings, both of which were significant at $P < 0.05$.

The levels of P and K interacted in their effect on sprout number per tuber ($P < 0.01$) (Table 4.8). There was a reversal of the response to an increase in P or K according to the level of the other with which it was in combination. The relative size of the responses determines the main effects of P and K.

The greatest number of sprouts was from the K_1 P_2 treatment and K_2 P_2 was exceeded by all except K_1 P_1 with which it was equal (P_2 $K_1 > P_1$ $K_2 > P_1$ K_1, P_2 K_2). This is the inverse of the interaction of P and K on % N.

Table 7.2.1. The effect of K and N on the number of sprouts per tuber.

		N_o	N_1	N_2	N_3	N_4	
Units N/acre		0	50	100	150	200	Mean
K_1	135	2.84	2.44	2.89	2.42	3.06	2.73
K_2	270	2.07	2.78	2.66	2.79	2.40	2.54
Mean		2.46	2.61	2.77	2.60	2.73	

S E for means of N ± 0.073

S E for means of K ± 0.036

S E for horizontal comparisons within table ± 0.103

S E for vertical comparisons within table ± 0.099

Main effect of N sig($P < .05$)

Main effect of K sig($P < .01$)

Interaction of K and N sig($P < .01$)

The K N quadratic interaction was significant ($P < 0.01$), (Table 7.2.1). At the higher level of K, the extremes of N, nil and 200 units N/acre, produced fewer sprouts than the intermediate levels of N/acre. At the lower level of K the effect of N was reversed in so far as the extremes produced the higher number of sprouts but were equalled by 100 units /acre, all these being higher than 50 or 150 units N/acre. Thus the main effect of N (+ve linear) does not hold at either of the levels of K tested.

The effect of the level of N on the response to increased K was that K_1 exceeded K_2 at nil and 200 units N/acre whereas at 50 and 150 units K_2 exceeded K_1 and at 100 units N/acre K_1 equalled K_2 in the production of sprouts.

This depression of sprout number with the higher level of K in combination with nil or 200 units N/acre was seen each year (Section 6.2.1), the effect of K at intermediate rates of N was indeterminate. In 1965 - 66 this effect was complicated by the N P K interaction (Section 6.2.1).

7.2.2. <u>The effect of N P K on the total length of sprout per tuber</u>.

The total length of sprout per tuber followed broadly the same pattern as the sprout number in its response to the treatments. As in previous years there was an increase in total length of sprouts with increased N, this at a higher level of significance (N linear $P < 0.01$) (Table 4.9). A quadratic effect ($P < 0.05$) arose from the lower total length of sprout at 150 units N/acre relative to 100 units N/acre and 200 units N/acre. The higher rate of K depressed the total length of sprout ($P < 0.01$) as it had the number of sprouts (Table 4.10). However the level of N interacted with K (KN quadratic $P < 0.01$) (Table 7.2.2) in such a way that K_1 produced a 25% greater total length of sprout than K_2 at nil and 200 units N/acre, but did not differ significantly at intermediate levels of N. The number of sprouts per tuber had been affected in the same way by K and N levels.

Table 7.2.2. The effect of K and N on the total length of sprout per tuber.

		N_o	N_1	N_2	N_3	N_4	
Units N/acre		0	50	100	150	200	Mean
K_1	135	31.1	31.0	36.6	31.7	40.5	34.2
K_2	270	25.9	32.3	34.9	35.2	32.1	32.1
Mean		28.5	31.7	35.7	33.4	36.3	

S E for mean of N $\pm$ 0.93

S E for mean of K $\pm$ 0.46

S E for horizontal comparisons within table $\pm$ 1.32

S E for vertical comparisons within table $\pm$ 1.27

Main effects and interaction of K and N sig $P < .01$

The main effect of increasing N of producing a greater total length of sprout was present at the K_1 level, but the total length of sprout from 150 units N/acre was low. This is a reflection of the low sprout number in part (Table 7.2.1).

At the K_2 level increasing N increased sprout length up to 150 units N/acre, but 200 units acre produced a shorter total length, a fact also in part a reflection of sprout number. Corresponding effects of the interaction of K and N were seen in the analysis of the seed for N % or D M %.

7.2.3. The effect of N on mean length of sprouts.

There was a positive linear effect of N ($P < 0.01$), the nil and 50 units N/acre treatments were shorter than all greater rates of N (Table 4.11). Thus nil N produced few and short sprouts (as in 1965-66, section 6.2), 50 units N/acre produced a small increase in sprout number and in mean length (and a small rise in seed tuber % N), 100 units N acre produced significantly more sprouts than nil N and sprouts of longer mean length than either nil or 50 units N, and 150 units N produced fewer sprouts than 100 units N/acre, the same as 50 units and not significantly more than nil N, but of greater mean length than all lower rates of N. 200 units N/acre produced a similar number of sprouts as 150 units N, but of greater length than from lower rates of N. There was an interaction of N with K, discussed later in this section.

Neither P nor K affected the mean length of sprout. The P K interaction was significant at $P < 0.01$ and followed an inverse trend to that seen with number of sprouts (Table 4.12). The higher rate of P reduced mean length of sprout at the lower level of K but increased it at the higher level. The higher level of K reduced the mean length of sprout at the lower level of P, but at the higher level of P it produced longer sprouts.

The K N quadratic and cubic interactions were significant at $P < 0.05$ (Table 7.2.3).

Table 7.2.3. The effect of K and N on the mean length of sprout (m m).

		N_o	N_1	N_2	N_3	N_4	
Units	N/acre	0	50	100	150	200	Mean
K_1	135	11.82	12.69	12.71	13.50	13.25	12.64
K_2	270	12.41	11.46	13.20	12.64	13.51	13.41
	Mean	11.72	12.07	12.96	13.07	13.38	

S E for mean of N $\pm$ 0.24

S E for mean of K $\pm$ 0.28

S E for horizontal comparisons within table $\pm$ 0.34

S E for vertical comparisons within table $\pm$ 0.40

At K_1, the sprout length is increased by increasing applications of N to the parent crop, but at K_2, the effect of N is indeterminate. Comparing the sprout numbers with mean length of sprout, at different levels of N in combination with one level of K, there is further evidence that while high sprout numbers leads to shorter sprouts, increased N compensates for this effect. It can be presented in terms of competition between sprouts at different nutrient levels, in which case sprout length is dependent on sprout numbers, and to a lesser extent on the tuber N content. It could be a reflection of quicker growth of the first sprouts causing a relatively higher degree of apical dominance, and therefore fewer sprouts

on those tubers which first sprout, leading subsequently to a greater growth of those few sprouts. However it is to be expected that the first sprouts on the high N tubers would grow faster than on the low N and would therefore show fewer sprouts on high N. This was not the case.

7.3. The effect of N P K applied to the parent crop on the emergence of the progeny.

Emergence counts were made when about 20% of the crop had emerged. The positive linear effect of N was significant (Sig $P < 0.01$) (Table 4.13) as in the previous year. The cubic effect was significant ($P < 0.05$), both N_1 and N_4 were slightly lower than the respective preceding levels, N_0, and N_2 and N_3. As in the previous year P_1 plots emerged earlier than the P_2 plots ($P < 0.05$) (Table 4.14). In this year there was no P K interaction but the slowest emergence was found in P_2 K_2.

1st sampling, 1966-67.

7.4. The effect of N P K applied to the parent crop on the progeny at the first sampling.

The first sampling took place 8 weeks after planting.

7.4.1. The effect of N P K on the weight of D M in leaves and stems at 1st sampling.

There was a linear increase in dry weight of stems and leaves with increasing N treatments ($P < 0.01$) (Table 4.15). Neither P nor K had a significant effect nor were any interactions significant, but there was a depression with P_2 K_2.

7.4.2. The effect of N P K on the D M in the roots at 1st sampling.

There was a linear increase in dry weight of roots with increasing N (Sig $P < 0.05$) (Table 4.16). Neither P nor K had a significant effect nor were any interactions significant.

7.4.3. The effect of N P K on the total D M (g) per hill at the 1st sampling.

The rate of N P K applied to the parent crop did not influence the total weight of dry matter per plant (stems + leaves + stolons + roots + seed tuber) (Table 7.4.3).

Table 7.4.3. The effect of N on the total weight of D M (g) per plant at the 1st sampling.

	N_o	N_1	N_2	N_3	N_4	
Units N/acre	0	50	100	150	200	S E
	11.73	11.47	11.76	12.06	11.67	± 0.406

1st and 2nd sampling 1966-67

7.5. The effect of N P K applied to the parent crop on the number of mainstems per hill in the progeny - combined results from 1st and 2nd sampling.

There was a small but significant ($P < 0.05$) positive linear response to increasing application of N. (Table 4.19). This trend was not apparent in previous years.

Neither P nor K effects were significant although as in the previous two years K_2 depressed the number of mainstems (sig 1965-66 $P < 0.05$) (Table 4.20). This effect of K was seen in the number of sprouts per tuber before planting.

The effects on the number of mainstems per hill of P and K interacted (sig $P < 0.01$), in a similar way to the effect of the P K interaction on the number of sprouts per tuber.

The greatest number of mainstems, as it was for sprout numbers, was from the K_1 P_2 treatment, (K_1 P_2, K_2 $P_1 > P_1$ K_1, K_2 P_2).

2nd sampling 1966-67.

7.6. The effect of N P K applied to the parent crop on the progeny crop at the second sampling.

The second sampling was made 11 weeks after planting.

7.6.1. The effect of N P K on weight of dry matter per hill on the leaves and stems.

7.6.2. The weight of dry matter per hill in the roots at the 2nd sampling.

None of the treatments significantly affected the weight of dry matter in either the stems and leaves or in the roots at the second sampling.

7.6.3. The effect of N P K on the yield (fresh wt) of tubers at the 2nd sampling.

As in the previous year, there was an increase in yield of tubers from increased applications of N to the parent crop (N linear $P < 0.01$) (Table 4.22). The level of P and K did not affect yield but P interacted with N (P N interaction linear and residual sig $P < 0.05$) (Table 7.6.3).

Table 7.6.3. <u>The effect of P and N on the yield (fresh wt.g) of tubers at the 2nd sampling.</u>

		N_o	N_1	N_2	N_3	N_4	
Units /acre		0	50	100	150	200	Mean
P_1	90	84.6	90.5	85.4	110.6	92.8	92.8
P_2	180	70.0	57.0	98.8	95.5	108.5	85.4
	Mean	77.3	73.7	92.1	103.1	100.6	

S E for mean of N ± 5.61 F Test sig ($P < 0.01$) for N

S E for mean of P ± 7.45

S E for horizontal comparisons within table ± 7.94

S E for vertical comparisons within table ± 10.29

Interaction of P and N sig ($P < .05$)

At N_1, P_1 outyielded P_2 by a significant amount, at all other levels of N there was no significant difference and the direction of the P effect was erratic. The low yield from N_1 P_2 also occurred in the foliage growth at the 1st and 2nd samplings.

7.6.4. <u>The effect of N P K on the number of tubers per plant at the second sampling.</u>

The N treatments did not affect the number of tubers (Table 4.23). The higher rate of K reduced the number of tubers per plant ($P < 0.05$) from 16.69 with K_1 to 14.69 with K_2 (Table 4.24).

7.6.5. The effect of N P K on the total dry matter per hill at the 2nd sampling.

The total weight of dry matter (stems + roots + tubers) per plant increased linearly with increasing N treatments ($P < 0.01$). This was significant at a higher level of probability than the linear effect of N on tuber weight, the variation of which contributes most of the effect. Neither P nor K had a significant effect, nor were any interactions significant.

Table 7.6.5. The effect of N on the total D M (g) per hill at the 2nd sampling.

	N_0	N_1	N_2	N_3	N_4		F Sig	C V
Units N/acre	0	50	100	150	200	S E	P <	%
	58.85	55.76	62.45	63.43	63.76	±1.661	L .01	10.9

1966-67 3rd Sampling.

7.7. The effect of N P K applications to the mother crop on the growth of the progeny at the third sampling.

The third sampling took place 16 weeks after planting.

7.7.1. The effect of N P K on the yield of tubers per plant at the third sampling.

The linear effect of N on tuber yield seen at the previous sampling was not present at the 3rd sampling when N had no significant effect on yield (Table 4.28).

The P_1 treatment outyielded P_2 (sig $P < 0.01$) (Table 4.29). The P K interaction was significant ($P < 0.05$), P_1 exceeded P_2 only in combination with K_2; similarly K_1 exceeded K_2 at the P_2 level.

7.7.2. The effect of N on the number of tubers per hill.

The N treatments had no effect on the number of tubers (Table 4.26). The main effects of P and K were not significant but the P K interaction was significant ($P < 0.01$) (Table 4.27).

7.7.3. The effect of N P K on the fresh weight of foliage.

None of the treatments affected the weight of above-ground foliage and stems.

7.8. The effect of N P K applied to the parent crop on the number of tubers and yield from the progeny at final harvest.

7.8.1. The effect of N on the number of tubers at final harvest.

The number of tubers per acre was unaffected by the rate of N applied to the parent crop in the previous year (Table 4.32).

The main effects of P and K were not significant but their interaction was sig ($P < 0.05$) (Table 4.33). The lower rate of K produced more tubers than the higher rate when both were in combination with P_2. At the lower rate of P the number of tubers was unaffected by the level of K. The number of tubers from P_1 equalled that from P_2 at both levels of K. The effect on tuber numbers of an increase in the level of P varied with the level of N (P N residual sig $P < 0.05$) (Table 7.8.1). The number of tubers from P_1 exceeded that from P_2 at N_o, and N_3, but was less than the number from P_2 at N_1, N_2 and N_4. None of these differences were significant.

Table 7.8.1. The effect of P and N on the number ('000) of tubers per acre at final harvest.

		N_o	N_1	N_2	N_3	N_4
Units /acre N		0	50	100	150	200
P_1	90	157.15	153.14	153.07	169.26	148.62
P_2	180	145.70	155.11	156.57	152.48	163.20
	Mean	151.43	154.13	154.82	160.87	155.91

S E for mean of N ± 3.827

S E for horizontal comparisons within table ± 5.143

S E for vertical comparisons within table ± 5.786

The highest number of tubers was from P_1 N_3 which was significantly greater than P_1 N_4, at the P_2 level P_2 N_4 yielded a greater number of tubers than P_2 N_o.

7.8.2. The effect of N P K on the yield (fresh weight) of tubers per acre at final harvest.

There was no evidence that the level of N had an effect on yield (Table 4.30). The yield was reduced by increasing K ($P < 0.05$) and this effect was unaffected by the levels of P (Table 4.31).

The P N interaction was significant ($P < 0.05$), the yield from P_1 exceeded the yield from P_2 only at N_1, N_3 and N_4 and only the difference at N_1 was significant (Table 7.8.2).

Table 7.8.2. The effect of P and N on the yield of tubers (tons/acre) at the final harvest.

		N_0	N_1	N_2	N_3	N_4	
Units /acre N		0	50	100	150	200	Mean
P_1	90	21.96	23.45	22.06	22.70	21.46	22.32
P_2	180	23.11	20.98	22.67	21.58	21.41	21.95
	Mean	22.54	22.21	22.37	22.14	21.43	

S E for mean of N $\pm$ 0.474

S E for mean of P $\pm$ 0.342

S E for horizontal comparisons within table $\pm$ 0.670

S E for vertical comparisons within table $\pm$ 0.690

Interaction of P and N sig. ($P < .05$)

At the P_1 level, P_1 N_1 outyielded all other levels of N, but only the difference from P_1 N_4 was significant. at the P_2 level P_2 N_o outyielded all other levels of N, but only the difference with P_2 N_1 was significant. The relatively low yield from P_2 N_1 was established by the second (11 weeks) sampling, (Table 7.6.3.) and the foliage growth from this treatment at 8 and 11 weeks was also low. Mainstem numbers (1st and 2nd sampling combined) were average.

By the third sampling, (16 weeks) this treatment (P_2 N_1) was also low in yield, but at this stage all levels of N with P_2 treatments gave lower yields than the corresponding N level at P_1. Thus the 16 week sample yields show a poor correspondance with final yields, while the 11 weeks samples show a rather better agreement.

Experiment 3 - Summary of 1967 Results.

As in the previous years, increasing N applications to the parent crop increased the % N in the dry matter of the seed tubers (Fig. 1). Increased K increased % N in the D M but only in combination with P_2 (Table 4.2). Increased N depressed the dry matter of the seed tubers produced (Fig. 1), as did increased K (Table 4.6). The % N in the fresh weight of tubers was increased by increasing N applications (Fig.1) and the nitrogen content was greatest with P_1 K_1 and P_2 K_2 ($P < 0.01$) (Table 4.4). The % N in the fresh weight was reduced by increasing P in combination with 0, 50 and 200 units N/acre and increased at 100 and 150 units/acre (Table 7.1.3).

When the seed was sprouted it was found that the number of sprouts per tuber was increased by an increase in N, but when the two K levels were separated (Table 7.2.1), this main effect of N was seen as the interaction of two opposing quadratics, positive at K_2 and negative at K_1 although even this effect was not distinct. Thus the main effect of K, where $K_1 > K_2$, was true only at N_0 and N_4 a feature noted in previous years.

It was also found that K_1 produced more sprouts than K_2 in combination with P_2 (seen in previous years) and the effect of P_2 of increasing the sprout number held only in combination with K_1 (Table 4.8).

The total length of sprout per tuber followed a similar pattern in response to N P K; it was increased by increasing N (Table 4.9). Increased K depressed the total length of sprout per tuber (Table 4.10), and as with sprout number this effect was significant only at N_0 and N_4 (Table 7.2.2).(Fig.2).

The mean length of sprout was increased by increasing applications of N to the parent crop ($P < 0.01$) (Fig.2). Thus increased N applications increased both the number of sprouts and the mean length of sprout per tuber. The main effects of P and K on mean length of sprout were not significant but the interactions were (Table 4.12). The mean length of sprouts was affected by the P K interaction in an inverse relationship to the effect of P K on sprout number (Table 4.8). Thus where the effect of N is removed by averaging over all levels of N, such as with the P and K means, the mean length of sprout is inversely related to the number of sprouts. But where the effect of % N in the tuber is interacting with the effect of sprout number, the reduction in mean length of sprout due to increasing sprout numbers is less where the % N in the tuber is high,than where it is low.

Emergence counts at a point in time during the emergence process showed that increased N increased the rate of emergence (Table 4.13), but there was a slightly lower emergence rate at N_1 and N_4 than at preceding levels of N in each case.

As in the previous year the P_2 plots emerged more slowly than P_1 (Table 4.14), and P_2 K_2 tended to be slowest. Foliage growth, as expressed by the weight of dry matter in the stems, leaves and stolons, was increased by increasing N, 8 weeks after planting (Table 4.15). Three weeks later, when tuber initiation had occured this effect was not evident (Table 4.21), nor was fresh weight of foliage affected by any treatment 16 weeks after planting. There was a small but significant increase in the number of mainstems per hill, when 1st and 2nd samplings were combined, with increasing N (Table 4.19). The high rate of K, as in previous years, tended to depress the number of mainstems as it had the number of sprouts per tuber before planting. The P K interaction (Table 4.20) also operated on mainstem numbers in the same way as it had done on sprout numbers, and also on the % N in the D M of the seed tubers, K_1 P_2, K_2 $P_1 > P_1$ K_1, P_2 K_2.

Root growth was increased by increasing N but only at the sampling 8 weeks after planting (Table 4.16).

The yield of tubers at the second sampling was increased by increasing N (Table 4.22), but by the 3rd and the final samplings the level of N had no effect. The yield from N_1 P_2 was low (Table 7.6.3), and it was noted that foliage growth was poor on this treatment at 8 and 11 weeks after planting. This treatment gave a low final yield. As growth advanced (16 weeks after sampling) the linear effect of N disappeared and only the effect

of P_2 in reducing yield was significant (this was true at all N levels). There was an interaction of P with K, P_2 K_2 was outyielded by all the other combinations of P K. By final harvest P_1 yielded significantly more than P_2 only at N_1 (Table 7.8.2, as was previously commented. The lower K level outyielded the higher level ($P < 0.05$) and this was unaffected by the level of N.

The number of tubers per hill was unaffected by N at either of the samplings or final harvest. Increased K reduced the number of tubers per acre at 11 weeks sampling, and 16 weeks after planting the interaction of P K in their effect on tuber numbers, followed the same pattern as it had with mainstem and sprout numbers (Table 4.27), P_1 K_2, P_2 K_1 > P_1 K_1, P_2 K_2. This is the inverse of the effect of P and K on % N in the fresh weight of tubers.

CHAPTER 8

Discussion of 3 Years' Results

The effects of N.

Increasing rates of application of N fertiliser to the parent crop linearly increased the % N content of the tubers produced, both on a dry and fresh weight basis (Fig.1). The N content was higher in the seed produced in 1964 than in the other years and ranged from 0.27% N in the fresh weight with nil N applied, to 0.38% with 200 units N/acre with a mean of 0.34%. In 1965 the range of the means for N from N_o to N_4 was from 0.21% N to 0.37% N with a mean of 0.28% N. The final year produced tubers of even lower N content, 0.24% N with a range of from 0.21 to 0.29%, probably due to the very high rainfall during the latter part of the bulking period. Thus the N content of the 1964 tubers was 50% more than that of tubers produced in 1966, a fact which may well explain the lack of significant effects on the sprouting and early growth of the second generation of N in the 1965 growth year, rather more effect in 1966, and a marked response to tuber N in 1967.

The dry matter % of tubers produced in 1964 was high (mean = 22.2% D M) as was also the % N in the dry matter (1.54%), as compared with 1966 (% D M = 20.9 and % N in the D M 1.17).

The 1965 growth year treatments show no significant relationship with sprout numbers per tuber, total length of sprout per tuber, or mean length of sprout. It is possible that this was due to the high N content of the tubers reducing competition for N between sprouts. From this it follows that the effect of applied N on the 2nd generation, demonstrated in the years 1966 and 1967, may occur only at tuber N levels at or below those occuring in these years, if the mechanism of response to applied N is only through the effect on tuber N. The effect of N in 1965 on emergence and the effect on the plants, at subsequent samplings will not be discussed further because of the interference with the results of Blackleg and the variable cover given to the tubers after planting.

In 1966, increasing N applied to the parent crop had no significant effect on sprout numbers per tuber, although the nil N treatment produced a low number of sprouts.

In 1967 there was a positive response in the number of sprouts per tuber with increasing N, albeit of a low order. The number of sprouts per tuber in 1967 was low, indicating a higher degree of apical dominance in this year, as compared with the other years. The tuber sizes were similar in each year and would not account for the difference in sprout numbers (Table 8.1).

Table 8.1. The mean number of sprouts per tuber in three years.

Year	Number of sprouts per tuber
1965	7.24 ± 0.02
1966	3.74 ± 0.03
1967	2.73 ± 0.03

The number of sprouts per tuber is known to be controlled by a number of factors, time in storage, tuber weight, (Morris, 1966, Goodwin 1966), rate of sprout growth (Morris, 1966, Burton, 1960), temperature, light (Headford 1962). The tubers sprouted for planting in 1965 had already sprouted during storage in bags and were desprouted when they were boxed for sprouting on 15th January. They were thus physiologically older than those tubers planted in 1966 and 1967, which were not sprouted when boxed. The 1965 tubers would therefore produce more sprouts because of their greater physiological age at the time of sprout regrowth given that the conditions of sprouting, light, temperature and tuber size were similar.

The effect, on total and mean length of sprout, of N and sprout numbers is confounded. The number of sprouts and the total length of sprout per tuber and the mean length of sprout were increased by increasing N in 1967. In 1966 total sprout length per tuber was a positive linear function of N although at K_2 the relationship was weak. The % of plants emerged at a count made 5½ weeks after planting when an average of 72% of the plants emerged, was also a linear function of N in 1966.

The weight of dry matter in the stems and leaves at the 1st sampling in 1966 was not significantly related to the N treatments applied to the parent crop, in spite of earlier emergence with increasing N. The % N in the dry matter of the haulm was a positive function of N (Table 8.2). There was some evidence of competition for N such as was found in relation to sprouts by Headford (1961), who deduced intersprout competition for N from the fact that the largest sprouts had the highest % N in the D M. The greatest quantity of foliage was on the 200 units N plot, which had emerged first (Table 4.15) and which also had the highest % N in the D M.

Table 8.2. The effect of N on the % N in the D M of foliage at the 1st sampling, 1966.

	N_0	N_1	N_2	N_3	N_4		F Sig.
Units N/acre	0	50	100	150	200	S E	P <
	5.73	5.71	5.77	5.79	5.86	± 0.025	0.01

The mean weight of foliage per mainstem (Table 8.3) showed evidence of an increase with increased N.

Table 8.3. The effect of N on the mean weight (g) of D M per mainstem and number of mainstems at 1st sampling 1966.

	N_o	N_1	N_2	N_3	N_4	
Units N/acre	0	50	100	150	200	
Wt. g DM/ mainstem	2.48	2.61	2.75	2.55	2.93	
No. of main-stems per hill	3.1	3.1	2.9	2.9	3.2	$\pm$ 0.14

F test not significant at $P < 0.05$.

The higher mean weight of D M per mainstem at N_4, coupled with the slightly higher mainstem number, suggests that inter-sprout competition has been reduced by some factor related to N. The growing points of plants were on average 21 cm above the ground, and at this stage 94% of the dry matter of the plant is derived from the tuber (Milthorpe 1960, quoting Headford 1961, and Headford 1962). The competition between mainstems, up to this stage of growth, will have been primarily for tuber substrate, and will thus be influenced by the tuber N content (Headford 1962).

At the 2nd sampling the total weight of D M in the leaves and stems was a positive linear function of N (Table 4.21). The number of mainstems at the 2nd sampling was unrelated to N and the mean number of mainstems for the N treatments was almost constant, so the mean weight of D M per mainstem was a function of N (Table 8.4).

Table 8.4. The effect of N on the mean weight (g) of D M in each mainstem and the number of mainstems per hill at the 2nd sampling 1966.

	N_0	N_1	N_2	N_3	N_4	
Units N/acre	0	50	100	150	200	S E
Mean wt. g D M/mainstem	12.48	12.56	14.10	13.70	14.97	
No. of mainstems per hill	2.9	3.0	2.9	3.0	3.0	± 0.15

F not significant at $P < .05$

This confirms the possibility at the first sampling that there was competition for N, and that some factor related to the N treatment of the parent crop of the seed affected the competitive capacity of the mainstems. The increased growth of stems and leaves between the 1st and 2nd sampling (Table 8.5) with increased N treatment will in part be due to the higher % N found in the foliage at the 1st sampling (Table 8.2).

Table 8.5. The effect of N on the increase in the mean weight of D M (g) in leaves, stems and stolons per hill between 1st and 2nd sampling 1966.

	N_0	N_1	N_2	N_3	N_4
Units N/acre	0	50	100	150	200
	28.5	29.6	32.9	33.7	35.5

Since root growth is normally directly related to foliage growth, the enhanced growth with higher N may have been due to an increased rate of growth of roots with high N in the early stages of growth, undetected in this experiment because roots are so difficult to measure, and are readily lost when digging.

At the second sampling in 1966 there was an average 6.2 ± 0.37 tubers per plant, weighing in total 0.55 g ± 0.069 per plant, indicating that tuber initiation was in the very early stages. Tuber number was unaffected by N treatment, so although there was an increase in foliage yield at high N levels, (N_4 yielded 24% greater weight of D M than N_0,) this did not appear to have delayed tuber initiation. However since the high N treatments emerged earlier, they will have had a few days more photosynthesis, up to the time of tuber initiation, than the lower N treatments. The weight of tubers per hill was a positive function of N, presumably due to the greater amount of foliage per plant at the time of tuber initiation and the short period subsequent to this, on plants which had very similar number of tubers.

By the third sampling in 1966, when tubers weighed 664 g ± 10.8 per plant the effect of N on yield of tubers was no longer significant, although N_0 gave the lowest yield. The number of tubers per plant had risen to an average of 32.9 ± 0.67 per plant and was also not significantly affected by N. The P N linear interaction was significant; at P_1 there was a linear increase with increasing N. This could not be related to foliage weight or number of mainstems at earlier samplings.

In comparing the 1967 results with 1966, the difference in the stage of growth at the first two samplings is important. Growth, up to emergence and during the early stages of growth, was slower in 1967 than in 1966, although growth was rapid after tuber initiation. The first samplings were taken at the same stage of growth (Table 8.6), but the 2nd sampling was taken at a later stage of growth in 1967 than in 1966, tuber initiation being almost complete (tuber numbers at the 2nd and 3rd samplings were similar), whereas in 1966 the process of tuber initiation had just started.

Table 8.6. A comparison of stage of growth of plants at the 1st, 2nd and 3rd samplings in 1966 and 1967.

Operation and variates	Weeks after planting		Mean value of variate	
	1966	1967	1966	1967
Emergence count	5½	6½	72%	19%
1st sampling	7	8		
Wt Foliage D M g/hill			8.1	6.44
2nd sampling	9	11		
Wt Foliage D M g/hill			40.2	46.62
Wt tubers g/hill			0.55	89.3
Number of tubers /hill			6.2	15.69
3rd sampling				
number of tubers /hill	12	12	33	16.21

Emergence was earlier in the high N treatments in 1967, as in 1966. At the first sampling in 1967, in contrast to 1966, the weight of D M in stems and leaves was a positive linear function of N (Table 4.15), as was weight of D M in the roots (Table 4.16).

The change in the total weight of D M per seed tuber between the start of sprouting in January, and the total weight of dry matter per hill, including the residual D M in the parent tuber, at 1st sampling, is an estimate of the net loss due to respiration over the period. It is a net loss figure however, and represents the difference between the gross loss by respiration from the tuber and roots and the net gain by photosynthesis, with the translocation from tuber to foliage and root as a constant on either side of the balance as follows:-

net loss = D M Foliage and Roots + Residual D M in seed − Original D M in seed

= Gain in foliage and roots by translocation + net photosynthesis − Loss from seed by translocation + respiration loss

= net photosynthesis gain − respiration loss

The respiration loss in the right hand term includes respiration losses from the root.

The net loss is reduced by increasing rates of N applied to the parent crop in the previous year. (Table 8.7b) (N linear sig $P < 0.01$).

Table 8.7. The effect of N on:
a) the total plant D M including parent seed tuber at 1st sampling (g),
b) net respiration loss

	N_0	N_1	N_2	N_3	N_4	
Units N/acre	0	50	100	150	200	S E
a)	11.73	11.47	11.76	12.06	11.67	± 0.406
b)	-3.37	-2.96	-2.36	-1.82	-1.73	± 0.385

Headford (1962) has shown that the losses by respiration from the tuber and sprouts over a similar 4 month sprouting period, are small, 7% of the original weight of D M in the tuber. It is unlikely that the losses at this time will be greatly affected by the treatments, and in any case, the differences will be small in relation to subsequent losses (33% during early growth in Headford's case). Most of the differences between N treatments will arise from either or both 1) a shortening of the period in which respiration only is taking place between planting and emergence, and 2) an increase in the net photosynthetic gain after emergence caused by the more rapid increase in the shoot with higher tuber N. Which is the more important of 1) and 2) cannot be distinguished in this experiment. Analysis of covariance, with the effect of % emergence removed, had no effect on the level

of N,whereas adjustment to a constant level of tuber N reduced the level of significance of the N linear effect to $P < .05$ from $P < .01$.

The loss of dry matter from the seed tuber at all levels of N is similar, but constitutes a greater proportional loss of the original dry matter from the high N tubers (Table 8.8).

Table 8.8. The effect of N on the loss of D M from the parent tuber between pre-sprouting and 1st sampling
a) in g D M
b) the loss as a % of the original D M content of the tuber.

	N_o	N_1	N_2	N_3	N_4
Units N/acre	0	50	100	150	200
a)	-11.31	-10.98	-11.23	-11.08	-10.93
b)	67.9%	68.8%	71.7%	72.8%	74.8%

The fact that the residual D M in the parent seed was inversely related to the N treatment (Table 4.19) and therefore to the weight of D M in the haulm at the 1st sampling,clearly demonstrates that the limiting factor in growth supported by the parent tuber is not the dry matter and is almost certainly N.

At the second sampling, the total plant D M (at this sampling, excluding the parent seed tuber which had now been attacked by wet rot in many instances), was a positive linear function of N (Table 8.9a).

Table 8.9. The effect of N on:

a) the weight of D M /hill (leaves + stems + stolons + roots + tubers) at the second sampling (g)

b) the growth in total D M per hill between 1st and 2nd sampling. (g).

	N_o	N_1	N_2	N_3	N_4		F Sig.
Units N/acre	0	50	100	150	200	S E	P <
a)	58.85	55.76	62.45	63.43	63.76	± 1.661	0.01
b)	47.12	44.29	50.69	51.37	52.09	± 1.709	

The weight of D M in leaves and stems (at the 2nd sampling) is not significantly affected by N_1 as it had been at the 1st sampling (Table 4.21). Most of the differences in whole plant growth between the levels of N is accounted for by the differential production of tuber D M (Table 8.10a) The growth in foliage D M between 1st and 2nd sampling is not related to N (Table 8.10b).

In 1966 at the 1st sampling, increasing rates of N applied to the parent crop did not significantly affect the weight of D M in the foliage, but did increase the % N in the D M of the foliage. This potential growth from higher N content

was realised by the second sampling, when N increased foliage D M significantly, the increasing N applications had increased haulm growth by the 1st sampling and the early benefits of higher N had been achieved by this time, resulting in a uniform % N in the leaf and stem tissue.

Table 8.10. The effect of N on:
a) yield of tubers (g D M) at 2nd sampling (g)
b) on the growth of D M in the foliage between 1st and 2nd sampling 1967. (g)

Units N / acre	N_o 0	N_1 50	N_2 100	N_3 150	N_4 200	S E	F Sig. P <
a)	11.01	10.02	13.00	14.85	14.59	± 0.849	L .01
b)	40.72	38.59	41.06	40.19	40.48	± 1.357	

The growth of foliage on N_1 treatments was less than the growth on N_2, no other differences are significant.

What appears to have occurred is that the small advantage in foliage growth, accrueing from increasing N on the parent crop at the 1st sampling, has led to a more rapid growth in the early stages of tuberisation, as was found at the second sampling, but by this time the differences in foliage growth are no longer significant, although N_o and N_1 are still below the other levels of N.

The subsequent bulking rate of tubers between the 2nd and 3rd sampling is greater on the lower N treatments (Table 8.11).

Table 8.11. The effect of N on the bulking rate (g fresh wt /day) between the 2nd and 3rd sampling 1967.

	N_o	N_1	N_2	N_3	N_4		F Sig.
Units N/acre	0	50	100	150	200	S E	P<
	17.20	16.69	16.01	16.13	16.20	± 0.581	0.05

It had been found in 1966 that the N treatments affected the mean weight of D M per mainstem. Moorby, J. (1967) found that the weight of haulm per sprout was inversely related to the number of sprouts. This accounted for 88 - 98% of the variation in haulm weight per sprout, according to variety. The sprout is the nearest analogy to mainstem available in Moorby's work since he measured total above ground stems and not mainstems. Thus it could be expected that any increase in mainstem number would reduce the mean weight of each mainstem. However, it is possible that in the early stages of growth, the N content of the tuber would affect intermainstem competition for N, the reduction in mean weight per mainstem with increased sprout numbers would be lessened by increasing N substrate in the tuber. An examination of the means for N (Table 8.12) supports this to some extent.

Table 8.12. The effect of N applied to the parent crop on the mean weight of dry matter per mainstem (g) and the number of mainstems 1967 - 1st sampling.

	N_o	N_1	N_2	N_3	N_4
Units N/acre	0	50	100	150	200
Mean wt D M /mainstem g	2.62	2.33	2.66	3.08	2.97
Number of mainstems per hill	2.17	2.45	2.45	2.29	2.41

N_o produced only 2.17 mainstems per hill of an average weight 2.62 g, N_4 produced more mainstems per hill, 2.41, each of greater mean weight 2.97 g, which supports the thesis.

By the second sampling in 1967 the total D M in foliage is not influenced by N, the number of mainstems is increased by increasing N (sig $P < 0.05$), a feature of the sample, rather than any change in plant character which could have occurred in the interim between 1st and 2nd sampling. The mean weight of D M per mainstem is inversely related to N and to the number of mainstems (Table 8.13).

Table 8.13. The effect of N on the mean weight of mainstem (g) and the number of mainstems per hill at the 2nd sampling.

	N_o	N_1	N_2	N_3	N_4
Units /acre N	0	50	100	150	200
Mean weight of D M per mainstem	23.08	21.09	19.50	19.65	19.93
Number of mainstems per hill	2.01	2.10	2.44	2.40	2.39

There is in this case evidence of inter-mainstem competition without any interaction with N, competition by this stage being for external resource, light, soil nutrients and water, and not for internal seed tuber N.

The nitrogen content of the plants was determined on the seed tubers and on all parts of the plant at the 1st sampling in 1967, as previously mentioned. It had been found in 1966 that the % N in the D M of the foliage increased with increasing N applied to the parent crop, however, in 1967, N had no significant effect on % N in the foliage (Table 8.14).

Table 8.14. Effect of N on the % N in the D M of the foliage at 1st sampling, 1967.

	N_0	N_1	N_2	N_3	N_4
Units /acre N	0	50	100	150	200
	5.44	5.42	5.51	5.37	5.44

The total weight of N in the whole plant, including the seed tuber, was a positive linear function of N (Table 8.15a). The total weight of N in the seed tubers, before sprouting commenced, had also been related to the N treatments in the previous year in the same way. The gain in total N was also a function of the N treatments (Table 8.15c), but the linear effect did not quite reach significance at 5%. The seed tuber N content had fallen to a constant very low level (Table 8.15b).

Table 8. 15. The effect of N on:-

a) the total weight of N in the plant (g) at 1st sampling

b) N in the seed tuber at 1st sampling (g)

c) the gain in total plant N (g) between the pre-sprouting tuber and the 1st sampling.

	N_o	N_1	N_2	N_3	N_4		F Sig.
Units N/acre	0	50	100	150	200	S E	P <
		All	values	g of	N		
a)	0.36	0.36	0.40	0.44	0.44	± 0.010	0.01
b)	0.05	0.05	0.04	0.05	0.05	± 0.003	
c)	0.22	0.21	0.24	0.26	0.24	± 0.016	

The Effect of P and K

The most consistent effect over the 3 years of K on the analysis of the tubers was the depression of the D M % by K_2 as compared with K_1. This effect of K is widely confirmed in the literature; Simpson (1962), Cowie (1943), Van der Zaag (1969), Baerug (1961), Dickins et al (1962). K had little effect on the % N in the D M or % N in the fresh weight. P did not appear to influence any of these variates, but only in 1967 was a test of significance available for the effect of P and K on the analysis of the tubers. In 1967 the P K combinations P_1 K_1 and P_2 K_2 had a higher % N in the fresh weight than the other combinations of P and K. There was also an interaction between P and N in the effect of % N in the fresh weight, where no N had been applied; the P_1 treatment increased the N content in the tuber as compared with P_2.

Over the 3 years' experiment, the higher level of K consistently depressed the number of sprouts per tuber, but only in combination with N_0 or N_4 among the levels of N, and only in combination with P_2 rather than P_1. Walker (1966) found that K applied to the parent crop, reduced the number of eyes per tuber of a given weight, and although the dormancy broke sooner on K than N P plots, this did not entirely compensate in terms of sprout number per tuber. The higher level of P increased the number

of sprouts per tuber in 1965 and 1967, but reduced the number in 1966 , in which year the level of N affected the effect of P in a complex way (Table 6.2.1a,b).The only significant effect of P and K on the total length of sprout was in 1967 when the total length was depressed by K_2 but only in combination with N_o and N_4; this was a reflection of the effect of K and N on sprout numbers mentioned earlier. The mean length of sprout was greater from K_2 N_o than K_1 N_o, probably because sprout numbers were greater on the K_1 N_o plots; competition for tuber substrate reduced the mean length. At the N_4 level the difference in mean length of sprout between K_1 and K_2 was not significant, the greater N content of the N_4 tubers had reduced inter sprout competition, and had minimised, but had not entirely removed, the advantage of the low number of sprouts on the K_2 N_4 treatment. Also in 1967, the effect of the combination of P_2 K_2 in reducing sprout numbers, gave rise to a high mean length of sprout, and P_1 K_1 also had longer sprouts than P_1 K_2 on P_2 K_1. Both treatments with the longer sprouts had a high N % in the fresh weight. In 1965, P_2 reduced mean sprout length and K_2 increased mean sprout length.

In general the mean length of sprout was inversely related to the number of sprouts, except where a high tuber N content reduced competition between sprouts. The higher level of K, interacting with N or, in some instances P, had the effect of reducing sprout numbers.

In both 1966 and 1967 the P_2 treatments emerged later than P_1; this could not be related to mean length of sprout.

Neither P nor K had a significant effect on the weight of D M in stems and leaves and stolons or roots, nor on the N content of any part of the plant at the 1st sampling.

In 1967 the P K interaction significantly ($P < .01$) affected the weight of D M remaining in the seed tuber at the 1st sampling (Table 4.18), P_1 K_1 and P_2 K_2 retained the greatest quantity of D M. In the case of P_1 K_1 this high residual D M is related to the original high D M content, 21.9 % as compared with 20.2 or 21.0% in the other P K combinations (Table 4.1); the loss of D M between the original content and that at 1st sampling from this treatment was a little less than from the P_1 K_2 and P_2 K_1 treatment (Table 8.16).

Table 8.16. The loss of D M (g) from the parent tuber between the start of sprouting and the 1st sampling expressed as a % of the original weight of D M 1967.

		K_1	K_2	
		135	270	Mean
P_1	90	70.1	72.9	71.5
P_2	180	72.4	68.8	70.6
Mean		71.3	70.8	

The high residual D M in the case of P_2 K_2 (Table 4.18) which had a relatively low D M content before sprouting (Table 4.6) represents a slightly lower % loss of D M from the tuber (Table 8.16) possibly related to the low yield of D M in the foliage at the 1st sampling (Table 8.17).

Table 8.17. The weight of D M (g) in the stems, leaves and stolons at the first sampling 1967.

		K_1	K_2			
		135	270			
P_1	90	6.72	6.49	6.61	S E for means	± 0.191
P_2	180	6.65	5.88	6.26	S E for comparisons within table	± 0.270
Mean		6.69	6.18		C V 8.40%	

The difference between the weight of D M in the whole plant, including the remains of the parent tuber at the 1st sampling, and the weight of dry matter in the original tuber, was greatest in the P_1 K_1 treatment. Since this was a negative quantity it represents a net loss of D M.

This loss in whole plant D M when examined in relation to the N treatments was seen to be decreased by increasing N. Thus lower losses were associated with a high % N in the fresh weight, a function of N. The P K data was examined to see if the loss was associated with % N. In the case of the P K treatments the

range in % N in the fresh weight of seed tubers was small 0.23% - 0.26% and non-significant, however P_1 K_1, which had the greatest net loss of D M, also exhibited the highest original % N in the fresh weight of the tuber, the opposite of the effect seen in the N means. Differences between net D M loss at different P K levels were also very small, about the same as the response to one increment of 50 units of N. It was concluded that effect of P and K on the change in weight of D M between the parent tuber and the whole plant at 1st sampling, was negligible.

In 1965 and 1966 the number of mainstems per hill was depressed by the higher K level, but only in the case of large tubers.

In both these years the number of sprouts had been reduced by K_2 (difference significant only in 1967) with no interaction with tuber size. The tuber size x K interaction, whereby the small tubers produced the same number of mainstems at both levels of K, must have arisen from the failure of the small K_1 tubers to support the growth of the same proportion of the original sprouts into mainstems as did the small K_2 tubers.

The higher level of P reduced mainstem numbers in 1966, as it had earlier reduced the number of sprouts per tuber. In 1967 P_1 K_1 and P_2 K_2 produced fewer mainstems than the other combinations of P and K, and also P_1 K_1 and P_2 K_2 tubers had a higher % N in the

fresh weight, thus, either the increase in number of mainstems with increasing N application to the parent crop arose from some factor other than the nitrogen content of the tuber, or, as is more likely in view of the small effect of P and K on the N content of the tubers, the P K effect on the number of mainstems arose from some factor other than their effect on the nitrogen content of the parent tuber. In support of this latter contention, the effect of the P K interaction on N content of the tubers and on the mainstem numbers in the previous two years did not bear the same relationship as they had done in 1967.

The number of tubers per hill at the second sampling was reduced by the higher level of K in all 3 years, although only in the case of plants from large tubers in 1966, in which year the tuber size P K interaction was also significant. In 1966 the higher level of P also reduced tuber numbers at the 2nd sampling significantly. The higher level of P had delayed emergence in 1966, so the reduced number of tubers at the early stage of tuber initiation was a function of rate of development, rather than an inhibition of tuber formation per se.

The absence of significance of the P effect on the tuber numbers at the third sampling supports this contention. The effect of K_2 in reducing tuber numbers was also absent at the 3rd sampling in all three years, which suggests that the effect at the 2nd sampling is an expression of the time or rate of tuber

initiation. There was a weak relationship between mainstem numbers and tuber numbers in that K_2 and P_2 had reduced both these variates in 1966.

The number of tubers at final harvest was significantly affected by the P K interaction in 1965 and 1967, the tubers from P_2 K_1 treatments outnumbered those from P_1 K_1 and P_2 K_2 and in 1967 P_2 K_2 treatment produced fewer tubers than all other combinations of P and K, and had also produced the least number of mainstems.

The yield of tubers at the 2nd sampling was affected only by the higher level of P producing a lower yield than the lower level of P at N_1, an effect which persisted in the total yield at final harvest. At final harvest K_2 also reduced total yield as compared with K_1.

CHAPTER 9

Final Discussion

Increasing the N applied to the parent crop increases the N resources of the tubers produced. These resources provide a potential for more rapid growth in the early stages of development of the crop grown from these tubers.

The total length of sprout per tuber was a positive function of N in both years as was the mean length of sprout in 1967. The number of sprouts was also a positive function of N in 1967, normally the mean length of sprouts is inversely related to the number of sprouts per tuber (Morris 1966) so, in the 1967 experiment, the increased N content of the seed induced by increasing the rate of N application to the parent crop, has counteracted the inter-sprout competition effect. The fact that the dry matter content of the tubers was inversely related to the N content suggests that dry matter, other than N, was not limiting sprout growth. Edelman and Singh (1966) suggested that carbohydrates were not limiting to sprout growth.

In both 1966 and 1967 emergence was more rapid with increasing N, this could have been a result of the response to N in mean length of sprouts in 1967. Sadler (1961) found that the time from planting to emergence and tuber initiation was inversely proportional to sprout length. On the other hand, Bremner and Radley(1966) comparing different varieties which had produced different mean lengths

of sprout, found no correlation between sprout length and time to emergence. In 1966 the mean length of sprout was not a function of N but rate of emergence was, which suggests that the N supply in the tuber increased the rate of elongation of the stems after planting. The potential for growth represented by the quantity of N in the tuber had not been expressed in 1966 in mean sprout length, a measurement of a historical event in the life of the plant, taking place in an environment differing from that in which emergence was about to take place. The growth potential of the enchanced N supply was expressed during emergence where the environment allowed a rate of growth at which inter stem competition took place. Morris (1966) demonstrated that at 7° C there was no inter sprout competition, but at the greater rate of growth at 20° C inter sprout competition was evident, and it may be that this offers an explanation of the absence of a significant response to N in the mean length of sprout in 1966.

In 1966, when the plants were 21 cm high, the % N of the leaf and stem was increased by increasing N in the parent tuber, but the potential growth from this N was not expressed in the size of the leaf and stem system at this stage. Over the following two weeks, the shoots grew more rapidly with increasing N content and on the larger plants the newly initiated tubers grew more rapidly. There was no evidence that the time

of initiation was delayed by the greater foliage growth, confirming the suggestion by Ivins and Bremner (1967) that the apparent delay in initiation with high N applications is in fact a difference in bulking rate. In this case the shoot competition with the tubers for photosynthate was decreasing because the effect of the small increments in tuber N was attenuated, probably by dilution in the early increase in growth.

In 1967 the effect of tuber N was similar, but the phasing of expression of the growth potential of the N differed. At the sampling before tuber initiation higher tuber N had induced greater growth of shoots and the dilution effect of this on the N content was seen in the similar % N in the shoot system of all N treatments. The early increase in shoot size with increasing N content of the tuber again lead to an increased yield of tubers during the initiation phase. By the time the initiation process was almost over the size of shoot system was similar on all N treatments. There was subsequently more rapid bulking of tubers between the 11 and 16 week samplings on the lower N treatments, so the yield was similar on all treatments at 16 weeks and final harvest.

There is no obvious reason why the bulking rate between the 11 and 16 week samplings should be greater on the low N treatments when the shoot systems were similar in size on all. Bremner and Radley (1966) demonstrated a close relation-

ship between bulking rate and leaf area index (L) where L was less than 3, such as would be the case during much of the period. It is possible that the fact that the lower N treatments had overtaken the higher N treatments in foliage production, thus having a higher proportion of newly expanded leaves, had led to a higher N.A.R. for a brief period (Milthorpe and Moorby 1966). Bremner and Taha (1966) found that the early advantage in leaf area of plants from large tubers, over those grown from smaller tubers, was rapidly lost; an analogous situation to these experiments where tuber reserves differed in N content, rather than quantity of dry matter. The tuber weights differed in Bremner and Taha's experiments by as much as 250 - 300%, a much greater difference than was caused by the N treatments in this experiment and the differences in dry weight of plant in the early stages of growth were much greater. Yet the earlier initiation of tubers on the larger plants and consequent earlier competition for photosynthate between tubers and leaves, reduced the rate of leaf growth on the larger plants so that the initially smaller plants from the small tubers eventually equalled in size the plants from large tubers.

A similar process appears to have occurred in these experiments, so that yield was uniform on each treatment by the time the bulking rate curve became linear (Milthorpe and Moorby 1966).

The early differences in yield no longer pertained and all N treatments bulked at the same rate and produced similar final yields.

Bodlaender and Marinus(1969)found that in the variety Alpha, rooted sproutlings grown detached from the parent tuber can, under favourable growth conditions under long days, produce almost as high a yield as plants grown with the mother tuber still attached. Thus a major difference such as the presence or absence of a parent tuber can be compensated for by the potato plant under favourable conditions.

Experiments investigating the effect of different rates of N applied to the seed bed have found either a slight stimulation of growth of leaves at samplings before tuber initiation (Ivins and Bremner 1965) or a slight depression (Simpson et al 1965). In both cases there was a delay in bulking in the early stages of growth,with the higher N treatments in the case of Simpson et al, and with both N treatments in the case of Ivins and Bremner. The effect of N was most marked in both of these experiments in the later stages of the bulking period, the production of new, vigorous leaves continued to a later stage with increasing N applications, so bulking was prolonged. In the case of the experiment described in this thesis the effect of the N in the tuber was already attenuated by the end of tuber initiation and from the results can have had no effect on the bulking rate after the earliest stages of bulking.

Since the haulms were destroyed before maturity it is not known what effect there would have been on the length of the bulking period, but no differences between treatments in leaf senescence were evident.

The higher rate of K reduced the number of sprouts per tuber as had been found by Walker (1966). The reduction occured, however, only in combination with either no N or 200 units N/acre applied to the parent crop, and only in combination with the higher P application. Both P and K appeared to affect sprout numbers independently of their effect on the N content of the seed tuber since, in 1967, $P_1 K_1$ and $P_2 K_2$ both had higher N contents but lower sprout numbers than $P_1 K_2$ or $P_2 K_1$. High K also reduced mainstem numbers per hill in 1966 and in 1965 and 1967, in the case of plants from large tubers only. This latter interaction was also found by Walker (loc. cit.). The effect on tuber numbers of P and K was erratic but the trend, frequently significant, was for the combination of the high rates of P and K to reduce sprout number per tuber, the number of mainstems and the number of tubers per hill. At final harvest the higher rate of K reduced the total yield.

These experiments therefore confirm the finding of the authors quoted in the introduction and more recent experiments by Reichard (1964) and Schepers et al (1969) that the effect of the fertiliser treatment of the parent crop on the performance

of the progeny as seed in the following year is primarily seen in the early stages of growth. The effect on final yield is minor and erratic.

This experiment shows that there is no case for departure from the economic optimum application for production in the potato crop in order to impart a higher N content to the seed produced. There are real disadvantages in very high rates of P and K in combination, but the rate required to produce depression of mainstem numbers is probably beyond that likely to be encountered in practice.

The effect of parental fertiliser rates on the early stages of growth and development is of such an order, that in experimental work on different varieties involving growth analysis, care should be taken that no extreme differences existed in the fertiliser treatment of the parent crops.

It is probable that some of the growth advantage of English "once grown" seed over new Scottish or Irish seed lies in the higher rates of N used in production of the seed in England.

It is an important condition of these experiments that the effect of fertiliser treatments on the average weight of tuber within the usual seed grade 1¼ - 2¼" had been removed by more accurate sizing of seed.

CHAPTER 10

CONCLUSIONS

1. In the maincrop variety, Kerr's Pink, the rate of N applied to the parent crop, within the extremes of 0 - 200 units N/acre, did not affect the final yield of the crop grown from the tubers produced, in the 1967 experiment. In this experiment, similarly sized tubers were selected from each treatment. Had less closely graded seed been planted, it is possible that the greater average size of tuber, with increasing N applications, would have given rise to an effect caused by tuber size.

2. The effect of K, in the form of K Cl, was erratic and complex, but in 1967 the highest rate of K reduced the final yield. The application of 270 units K_2O/acre as opposed to 135 units K_2O/acre reduced the number of sprouts per tuber but only in combination with either no N, or 200 units N/acre, or in combination with 180 units P_2O_5 per acre, rather than 90 units P_2O_5/acre. The number of mainstems per hill was reduced by high K but in 1966 and 1966, only where tubers of $1\frac{3}{4}$ - $2\frac{1}{4}$" grade were planted, rather than $1\frac{1}{4}$ - $1\frac{3}{4}$" and the reduction tended to be greatest in combination with the higher rate of P. The number of tubers per hill, at a sampling near the time of tuber initiation, tended to be reduced by high K. However this effect appears to be a delay in tuber initiation, rather than a real reduction, since at a later sampling

in 1967 and at final harvest in 1965 and 1967 tuber numbers were lower on those treatments which combined either the highest or the lowest rates of P and K rather than on the combinations of high with low.

3. The application of 180 units P_2O_5/acre as superphosphate, rather than 90 units, increased the number of sprouts per tuber in 1965 and 1967, and reduced the rate of emergence. In 1966 the combination of the higher rates of P and K reduced the number of sprouts per tuber and the high rate of P reduced the number of mainstems.

4. An increase in the rate of N applied to the parent crop increased the total length of sprout per tuber before planting, and in one year increased both the number of sprouts per tuber and the mean length of sprout.

5. Increased N applied to the parent crop increased the tuber N reserves, giving a potential for faster early growth of shoots, greater rate of bulking of tubers during initiation, but the effect was of limited duration and the competition between tuber and shoot removed the early advantage of the higher N treatments.

6. Higher N reserves in the tuber reduced the net respiration loss between the time of sprouting and a stage of growth when the plants were 21 cm high, before tuber initiation. This was probably caused by a more rapid growth of shoots.

7. There was evidence of reduced competition between sprouts and between mainstems in the early stages of growth, arising from higher tuber N reserves, in the two years when the average N content of the tubers was lower. There was evidence that N rather than other constituents of the dry matter, such as carbohydrates, was the limiting factor on sprout and shoot growth, in the early stages of growth.

Addendum to References

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APPENDIX I

Statistical Analysis.

The initial analysis of variance was undertaken at Rothamsted by Dr. F. Yates. Only main effects and 1st and 2nd order interactions were analysed in this analysis. Further analysis was undertaken under Mr. R. Henderson and Mr. Shukla of the A. R. C. Unit of Statistics, Edinburgh, using Genfac II Rothamsted programme. In this case, linear, quadratic and in some cases cubic and quartic effects were calculated. In the analysis of variance of the first two years' results, four error terms were calculated (Table A.1). The error 1st term consisted of the tuber size and blocks interaction with one degree of freedom. No discussion of seed tuber size main effect is offered, tuber size having been introduced largely in order to reduce the experimental error due to variation arising from this factor, and to investigate the interaction with N and tuber size.

The second error term is appropriate to the sub-plots P and K and all interactions between P, K and T, (tuber size).

The third error term is appropriate to the sub-sub-plots containing the N main effect and the linear and quadratic effects of the interaction of N, P and K, and the fourth error term is appropriate to the linear and quadratic effects of all 1st, 2nd and 3rd order of tuber size (T).

This distinction of error terms 3 and 4 proved unnecessary and the 3rd and 4th error terms were pooled for the calculation of the variance ratio for all treatments and interactions below error 2 in the analysis of variance below.(Table A.1).

In the case of the 1967 results, the design changes resulted in a different analysis of variance (Table A.2) in which the first part of the analysis used tuber size as blocks, and used the interaction between P K combinations and seed size as error 1. The second part of the analysis concerned the sub-plot N main effect including the linear, quadratic, cubic and quartic terms. All interactions of tuber size were included in the 2nd error term.

Table A.1. Analysis of variance 1965 and 1966.

		Degrees of freedom
Replicates		1
Tuber size (T)		1
Error 1		1
P		1
K		1
P K		1
T P		1
T K		1
T P K		1
Error 2		6
(Effects)		
N	linear	1
N	quadratic	1
P N	linear	1
P N	quadratic	1
K N	linear	1
K N	quadratic	1
P K N	linear	1
P K N	quadratic	1
Error 3		8
T N	linear	1
T N	quadratic	1
T N	residual (cubic + quartic)	2
T P N	linear	1
T P N	quadratic	1
T P N	residual (cubic + quartic)	2
T K N	linear	1
T K N	quadratic	1
T K N	residual (cubic + quartic)	2
T P K N		4
Error 4		32
Total		79

Pooled error (Error 3 + Error 4) 40 degrees of freedom

Table A. 2. Analysis of variance 1967.

		Degrees of freedom
Blocks (tuber size)		3
P		1
K		1
P K		1
Error 1		9
(Effects)		
N	linear	1
N	quadratic	1
N	cubic	1
N	quartic	1
P N	linear	1
P N	quadratic	1
P N	cubic + quartic	2
K N	linear	1
K N	quadratic	1
K N	cubic + quartic	2
P K N	linear	1
P K N	quadratic	1
P K N	cubic + quartic	2
Error 2		48
Total		79